# Cisco Aironet 1600/2600/3600 Series Access Point Deployment Guide

AP 3600e
(external antennas)

AP 3600i
(internal antennas)

ABSTRACT: This document covers the theory of operation and installation for Cisco 2600 and 3600 Series Access Points (APs), as part of a Cisco wireless LAN (WLAN) solution. Subjects include:

- AP 1600, 2600, and 3600
- Differences between the AP 3600 and the AP 3500
- Differences between the AP 3600 and the AP 2600
- Introduction of the AP 1600 and AP feature comparison
- Hardware details, mounting options, bracket choices, and installation considerations
- Antenna options, radiation patterns, and external antenna deployments
- Spatial streams and MCS rates
- ClientLink 2.0 and Bring Your Own Device (BYOD)
- Site survey considerations
- Inappropriate installations, Q&As, and useful URLs

This document is intended for trained and experienced technical personnel familiar with the existing Cisco Wireless Networking Group (WNG) product line and features.

# Revision History

| | |
|---|---|
| Document Number: | EDCS-1188900 (replaces EDCS-1130881) |
| Document Author: | Frederick Niehaus (fredn) |
| Author's Organization: | WNG (WNBU) TME |
| Document Date / Version: | 12/12/12 version 3.0 |

# Table of Contents

# Cisco Aironet Series Access Points

Cisco Aironet 3600, 2600, 1600, and 600 Series Access Points (APs) provide highly secure and reliable wireless connections for both indoor and outdoor environments. Figure 1 illustrates the product portfolio, which ranges from the entry-level 600 Series for basic connectivity to the 3600 Series for best-in-class performance.
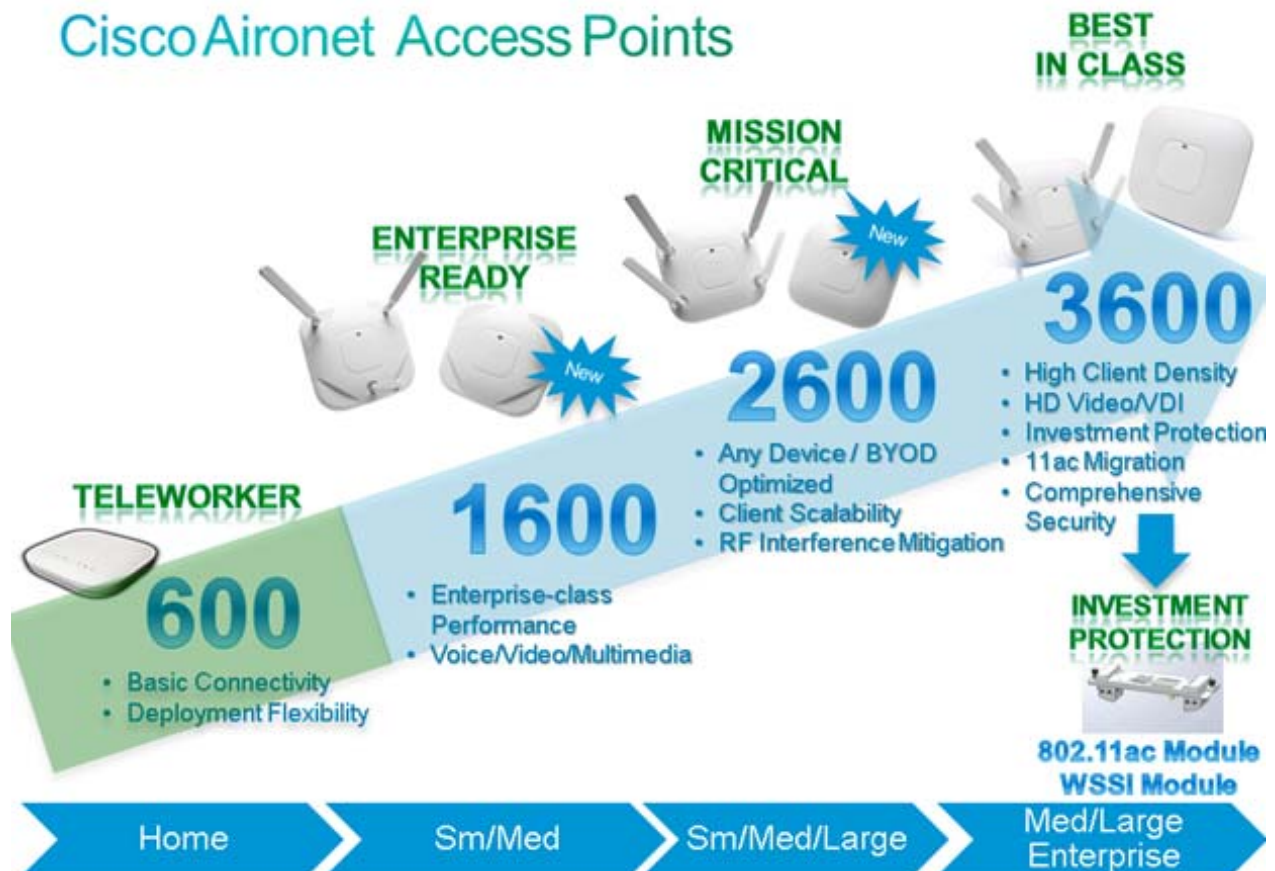


Figure 1: Access Point Portfolio Placement

## Internal and External Antennas

The 3600, 2600, and 1600 Series offer models with internal or external antennas. Figures 2, 3, and 4 describe the internal and external antenna models for each series.

- APs with internal antennas have an "i" (for example, AP 3600i) in the model number. They have captured antennas, which are part of the housing and not removable, and are designed for indoor enterprise installations where office aesthetics are a primary concern.
- APs with external antennas have an "e" (for example, AP 3600e) in the model number. They are more rugged and are designed for industrial use in locations such as hospitals, factories, warehouses, and other locations where there is a need for external antennas or extended operating temperatures. The external antenna models also support mounting inside NEMA enclosures for use in the most demanding environments.

Figure 2: AP 3600 Models and Eco-Packs



Figure 3: AP 2600 Models and Eco-Packs

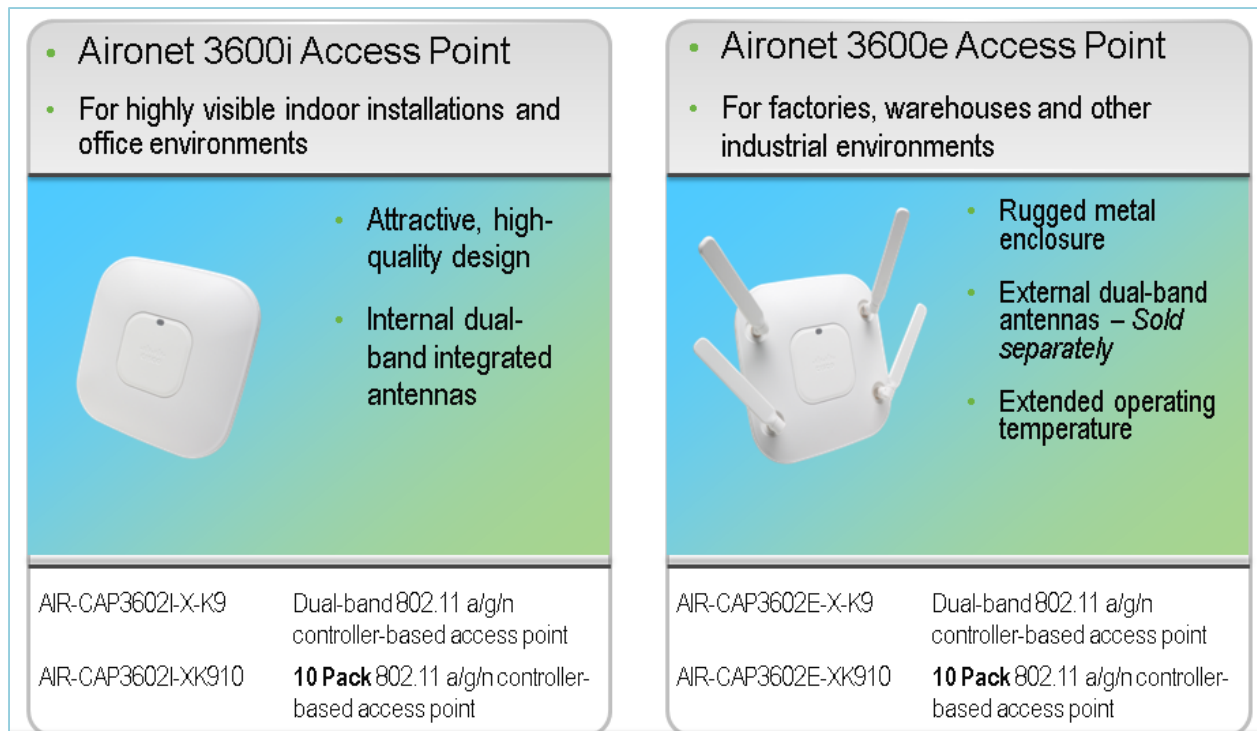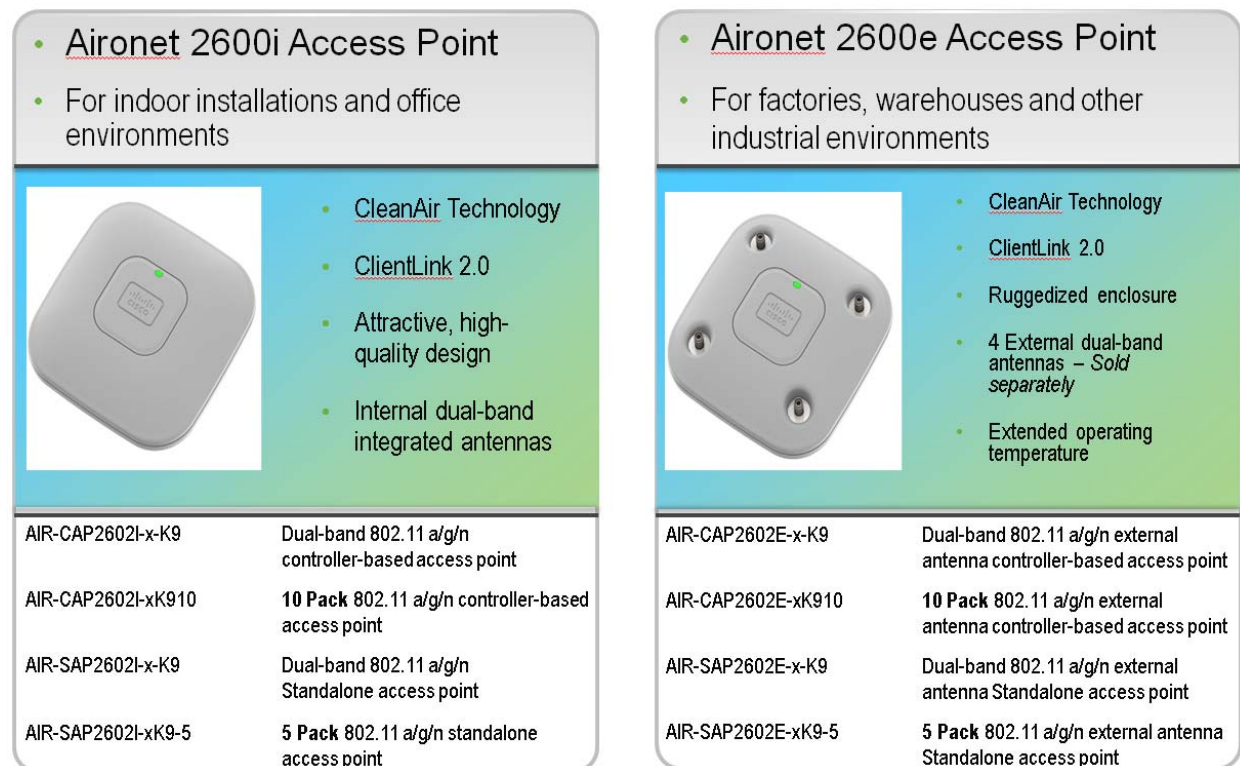- **Aironet 1600i Access Point**
- For entry-level 802.11n indoor installations and office environments

  - Attractive, high-quality design and RF performance
  - Clientlink 2.0
  - Internal dual-band integrated antennas

  *List Price: $695*

| AIR-CAP1602I-x-K9 | Dual-band 802.11 a/g/n controller-based access point |
| AIR-CAP1602I-xK910 | **10 Pack** 802.11 a/g/n controller-based access point |
| AIR-SAP1602I-x-K9 | Dual-band 802.11 a/g/n Autonomous access point |

- **Aironet 1600e Access Point**
- For entry-level 802.11n factories, warehouses and other industrial environments

  - Extended operating temperature
  - Clientlink 2.0
  - 3 External dual-band antennas *(Sold separately)*
  - Attractive, high-quality design and RF performance

  *List Price: $795*

| AIR-CAP1602E-x-K9 | Dual-band 802.11 a/g/n controller-based access point |
| AIR-CAP1602E-xK910 | **10 Pack** 802.11 a/g/n controller-based access point |
| AIR-SAP1602E-x-K9 | Dual-band 802.11 a/g/n Autonomous access point |

Figure 4: AP 1600 Models and Eco-Packs

## 3600 Series

The Cisco 3600 Series Access Point (AP 3600) targets customers who require support for mission-critical applications. The AP 3600 embodies ClientLink 2.0, an innovative antenna technology comprising four transmit radios and four receive radios called 4X4 Multiple Input Multiple Output (MIMO) and three spatial stream (3SS) beamforming, together referenced as 4x4:3. ClientLink 2.0 permits speeds up to 450 Mbps via additional Modulation and Coding Scheme (MCS) data rates 16-23, while still maintaining IEEE 802.3af (15.4 Watt) Power over Ethernet (PoE) compliance. See the section on "802.11n, Spatial Streams, and Beamforming" for more on spatial streams.

### Feature Modules for the 3600 Series

The WSSI (Wireless Security and Spread Spectrum Intelligence) module adds new functionalty to the AP 3600 to protect customer investment. This optional, add-on module provides a dedicated monitor radio to scan the full spectrum, not just the channel on which the AP operates. It offloads complete monitoring and security services to the monitor module, including CleanAir, WIDS/WIPS, Context-Aware Location, Rogue Detection, and Radio Resource Management (RRM). The WSSI module allows for full spectrum analysis on all channels on both the 2.4 and 5 GHz bands. It avoids the need to deploy a separate, dedicated overlay network for full spectrum monitoring and eliminates the need for an extra cable pull and additional infrastructure costs.

The second available module provides 802.11ac (wave-1) functionality to the AP 3600. This radio module operates at 5GHz and allows the AP 3600 to fully support 802.11a/n along with 802.11ac clients. (Wave-1) functionality supports a 1.3 Gbps PHY / ~1 Gbps MAC (throughput) using three spatial streams, 80 MHz, 256 QAM. It also supports Explicit Beamforming per the 802.11ac standard. Use of the radio

module may require a local power supply, Cisco power injector, .3at PoE+, or use of the Cisco Enhanced PoE because the module may draw power greater than 15.4W.

**Note**: Cisco Enhanced PoE was created by Cisco and is the forerunner to 802.3at PoE+.

Feature modules slide into the bottom of AP 3600, as shown in Figure 5.
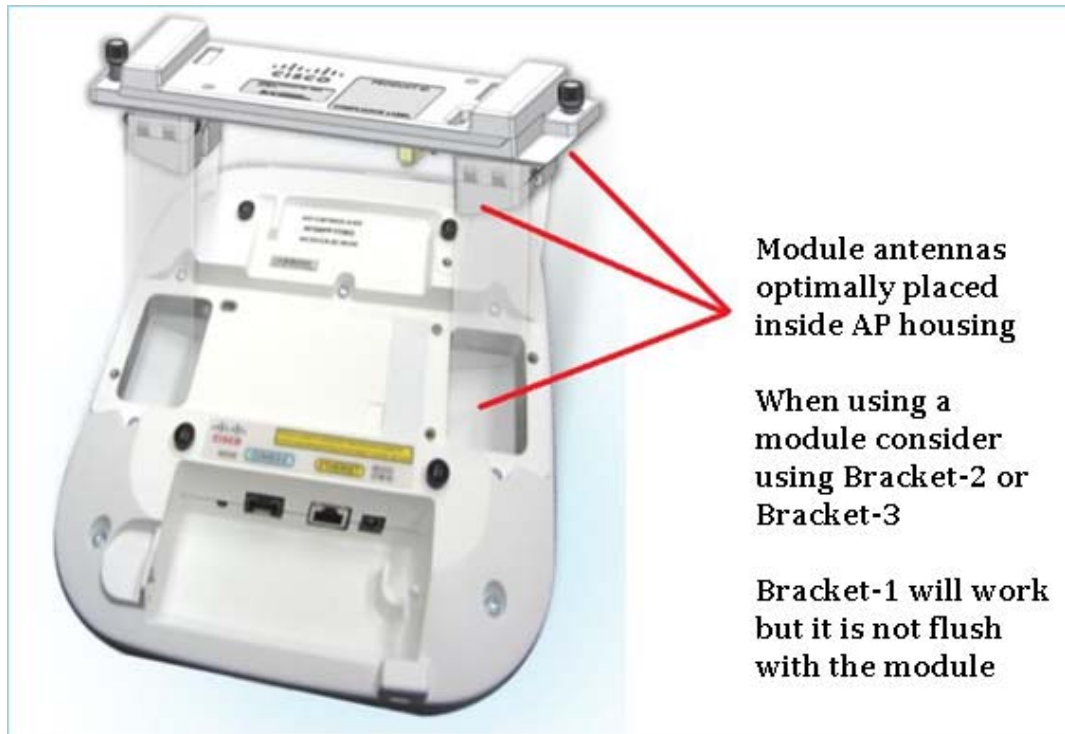


Figure 5: Back View of the AP 3600 with Feature Module

## Comparison of the 3600 and 3500 Series

The AP 3600i (internal antenna model) and the Cisco 3500 Series Access Point (AP 3500) are almost identical in physical appearance. To easily distinguish them, note that the LED for the AP 3500 is square, while the AP 3600i has an LED that is slightly larger and more oval. (See Figure 6.)

Figure 6: LED Appearance in the AP 3600i and the AP 3500

From a side view, the AP 3600i is slightly thicker (2.11") than the AP 3500 (1.84"), as shown in Figure 7. The thicker size allows for additional radio support and printed circuit board area, as well as feature modules for future capabilities. While the AP 3600i has a little more depth, it is completely backward compatible with the mounting brackets for the existing Cisco Aironet 1040 Series Access Point (AP 1040), 1140 Series Access Point (AP 1140), 1260 Series Access Point (AP 1260), and the AP 3500.



Figure 7: Side View of the AP 3600i and the AP 3500

The external antenna models (the AP 3600e and the AP 3500e) differ in appearance because the AP 3600e has fewer antenna connector ports, primarily due to the dual-band antenna system.

The AP 3600e has combined all the antenna ports (dual-band) so that each antenna port can transmit simultaneously on each band; if the antenna ports were not combined, this would have required eight antennas. The AP 3600 has four transceivers (transmitter/receiver) radio ports per band for a total of eight transceivers, four in each band. This additional radio per band permits beamforming to 3SS clients using ClientLink 2.0 to improve the overall performance of all 802.11n clients with one, two, and three spatial streams.

**Note**: Beamforming to a 3SS client requires n+1 radio frequency (RF) design. To accomplish this, the AP 3600 has an additional radio per band, which improves client performance by using Cisco ClientLink 2.0.

The AP 3500e has separate antennas for each band, 2.4 GHz and 5 GHz, and does not support 3SS technology, since it has only two transceivers (transmitter/receiver) and one extra receiver per band enabling operation up to two spatial streams.

Unlike the AP 3500, the newer AP 3600 design supports an optional, add-on feature module. The bottom of the AP 3600 has openings to support the feature module, as shown in Figure 8. The openings, while fully sealed, permit the module to have access to the top of the AP, which allows the module antennas (if present) to fully function. The unit includes a positive snap "spring loaded BB" so the installer can feel a positive lock when the AP is fully engaged in the bracket.
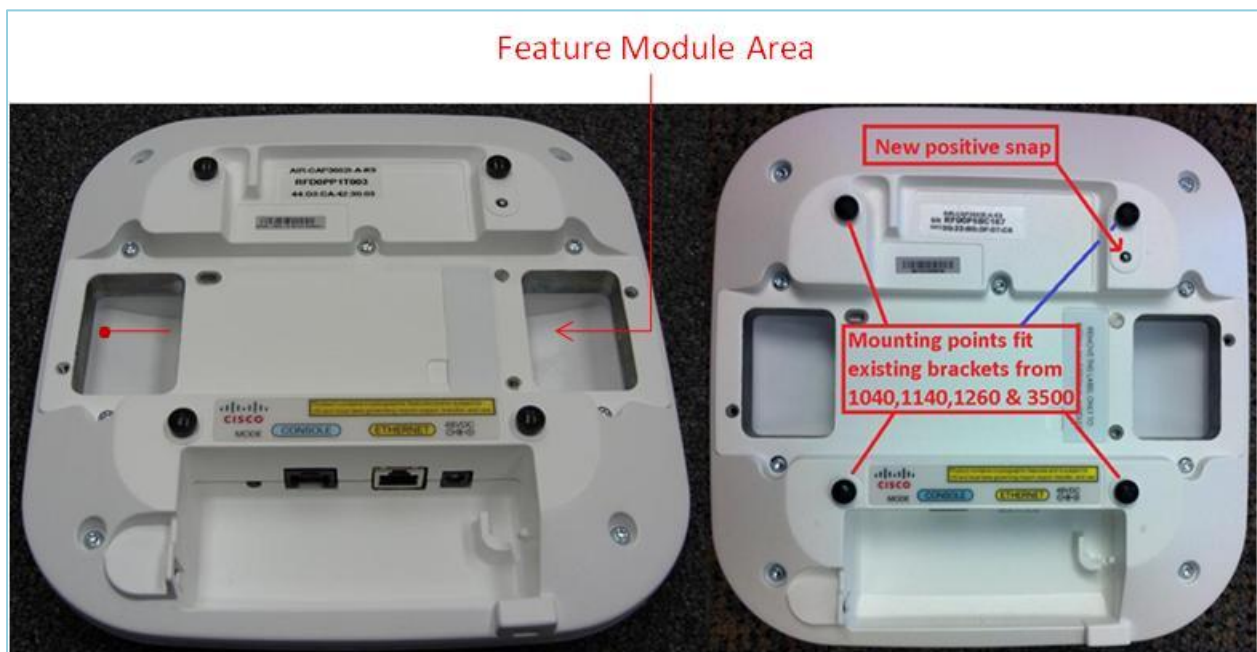


Figure 8: Bottom View of the AP 3600 with Support for a Feature Module

## Comparison of the 3600 and 2600 Series

The AP 3600 has a modular design that offers future protection with optional .11ac and security modules. The AP 2600 does not support optional modules. However, the AP 2600 does have a slightly higher antenna gain in the 2.4 GHz band.

The AP3600 and the AP2600 are the same size, but it is easy to identify each one by noting whether the Cisco logo has an embossed frame (AP 3600) or not (AP 2600). (See Figure 9.)

The AP 2600 from the front is identical to
The AP 3600 except the logo has an
embossed frame around it.

This allows you to identify it visually as
an AP 2600

Figure 9: Front View of the AP2600 and the AP 3600

The AP 2600 is a 3X4:3SS, so ClientLink does not beamform to 3SS clients; however, it does beamform at legacy, one, and two spatial stream rates. The AP 3600 is a 4X4:3SS, supporting an extra transmitter chain for additional downlink performance for all bands and clients. The AP 3600 has slightly higher performance and beamforms to legacy, one, two, and three spatial stream rates and .11ac rates when using the optional .11ac module.

The two series use the same mounting hardware and antennas. See Figure 10 for a back view.



AP-2600 does not
support modules

Figure 10: Back View of the AP 2600

Because of these similarities, there is no need to repeat a site survey for the AP 2600 if a survey exists for the AP 3600.

## Introduction to the 1600 Series

The Cisco Aironet 1600 Series Access Point (AP1600), shown in Figure 11, is a second generation, entry-level AP.

Figure 11: AP 1600

### Key Features

Significant features include:

- ClientLink 2.0
    - Adds a key function when upgrading from the AP 1040/1140 and the AP 1260
    - Supports 802.11n clients up to 1-SS
    - Supports 802.11a/b/g clients
    - Supports (beam-form) up to 32 clients per radio interface
- 3x3:2 architecture
    - Better performance than the 2x2:2 AP 1040
    - Better throughput performance than the AP 1140 and the AP 1260
- External antenna model for entry-level and mid-level market
- Up to 128 clients per radio for a total of 256 clients
- Different LED color change compared to earlier access points
- CleanAir Express – Basic Spectrum Analysis available soon via software upgrade

### Cisco CleanAir Express

Cisco CleanAir Express technology is enabled on the advanced silicon design of the AP 1600. With CleanAir Express, the AP 1600 has the ability to effectively detect RF interference, identify the source, locate it on a map, and make automatic adjustments to optimize wireless coverage. With CleanAir Express technology, organizations have a basic spectrum analysis capability to support their wireless networks while simplifying ongoing operations. (See Figure 12.)

## Spectrum Intelligence

| Access Point | CleanAir Express* AP-1600* | CleanAir AP-2600 or AP-3600 | CleanAir with WSSI AP-3600 with WSSI Module |
|---|---|---|---|
| Detection | • | • | • |
| Classification | • | • | • |
| Mitigation | • | • | • |
| Location | • | • | • |
| Performance Optimized | | • | • |
| Top Impacts and Severity List | | • | • |
| Alert Correlation | | • | • |
| Air Quality Index | | • | • |
| Zone of Impact | | • | • |
| Off Channel Scanning | | | • |
| Proactive Intelligent Channel Switching | | | • |

*Will be available via software upgrade*

Figure 12: Comparison of CleanAir Features in the 1600/2600/3600 Series

# Comparison of Indoor Access Points

A comparison of the indoor access points for the 3600/2600/1600/600 Series is shown in Figure 13.

## Cisco Aironet Indoor Access Point Comparison Matrix

| | 3600 Series | 2600 Series | 1600 Series | 600 Series |
|---|---|---|---|---|
| Max Data Rate | 1.3 Gbps | 450 Mbps | 300 Mbps | 300 Mbps |
| Radio Design MIMO:Spatial Stream | 11n: 4x4:3 11ac: 3x3:3 | 3X4:3 | 3X3:2 | 2X3:2 |
| CleanAir | Clean Air | Clean Air | Clean Air Express | |
| ClientLink (No. of Clients **) | ClientLink 2.0 (128) EBF for 802.11ac | ClientLink 2.0 (128) | ClientLink 2.0 (32) | |
| Max Clients (Per Radio) | 200 | 200 | 128 | 15 (total wireless) |
| BandSelect | ✔ | ✔ | ✔ | |
| VideoStream | ✔ | ✔ | ✔ | |
| Rogue AP Detection | ✔ | ✔ | ✔ | |
| Adaptive wIPS | ✔ | ✔ | ✔ | |
| OfficeExtend | ✔ | ✔ | ✔ | ✔ |
| FlexConnect | ✔ | ✔ | ✔ | |
| Wireless Mesh | ✔ | ✔ | ✔ | |
| Autonomous | ✔ | ✔ | ✔ | |
| Power | 11n: 802.3af 11ac: Enhanced PoE, 802.3at or UPoE | 802.3af | 802.3af    AC Adapter | 100 to 240 VAC, 50-60 Hz |
| Wi-Fi Standards | 802.11 a/b/g/n/ac | 802.11 a/b/g/n | 802.11 a/b/g/n | 802.11 a/b/g/n |

Figure 13: Comparison of the 3600/2600/1600/600 Series

# Hardware and Mounting Options

The AP 1600, 2600, and 3600 have the same mounting options and share similar dimensions, as shown in Figure 14. There are slight cosmetic differences; for example, there are three antennas on the AP 1600.
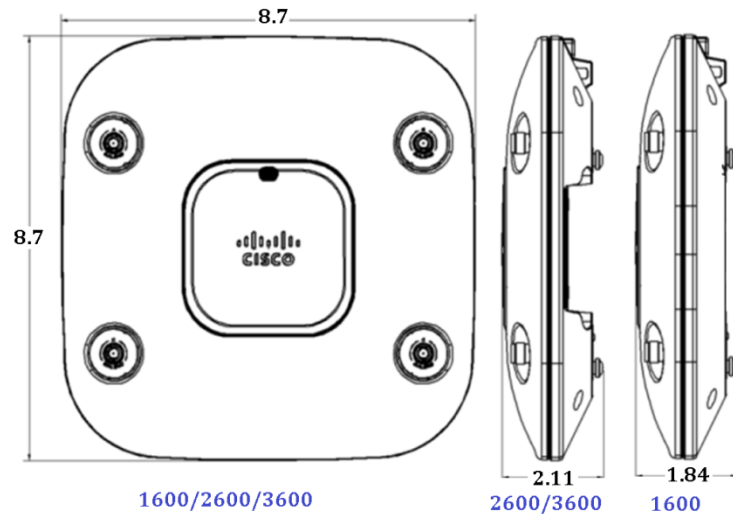


Figure 14: Mechanical Drawing of the AP 2600 and the AP 3600

## Brackets and Clips

There are many different installation options available depending upon the requirements of the customer. Brackets are available from Cisco as well as third-party companies. When ordering, the customer may choose either a low-profile or a universal bracket; both are shown in Figure 15. Each bracket is a zero-dollar ($0) option at the time of configuration.

If the customer does not choose a bracket, the default is the low-profile AIR-AP-BRACKET-1, which is the most popular bracket for ceiling installations. For the AP 3600, Cisco recommends using the universal bracket, part number AIR-AP-BRACKET-2.

**AIR-AP-BRACKET-1**
AP Bracket: Low-Profile

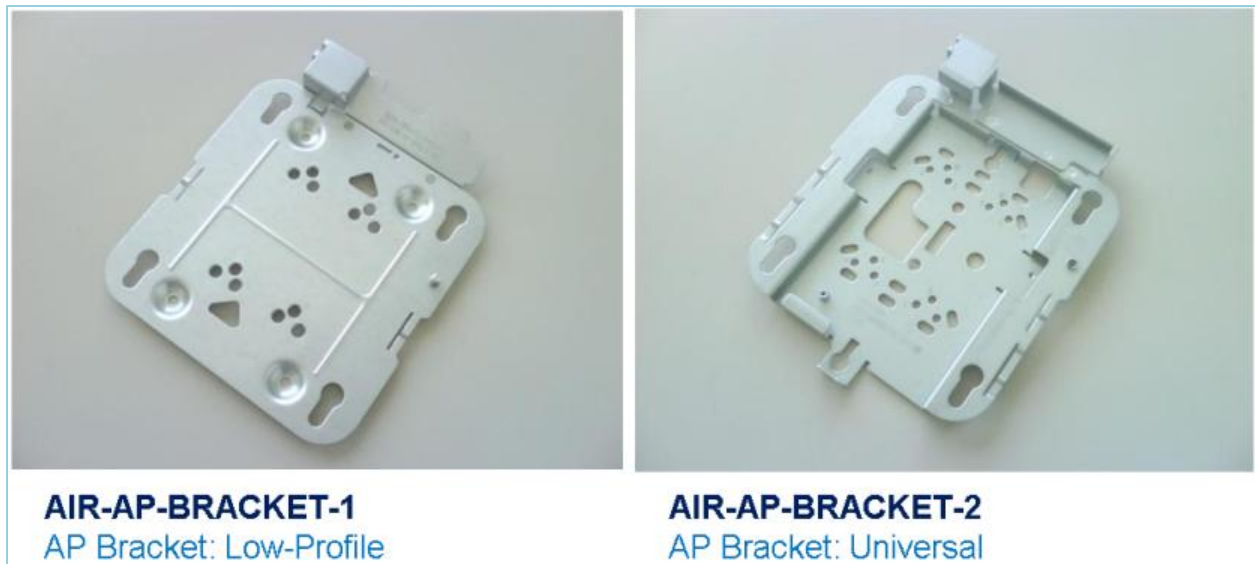**AIR-AP-BRACKET-2**
AP Bracket: Universal

Figure 15: Access Point Bracket Choices

If the AP needs to be mounted directly to a ceiling on the gridwork, AIR-AP-BRACKET-1 mounts flush and has the lowest profile. Since some ceiling tiles are recessed, two different styles of ceiling clips, recessed and flush rails, are available to mount the bracket to the ceiling gridwork. (See Figure 16).


**AIR-AP-T-RAIL-R**
Ceiling Grid Clip (Recessed)

**AIR-AP-T-RAIL-F**
Ceiling Grid Clip (Flush)
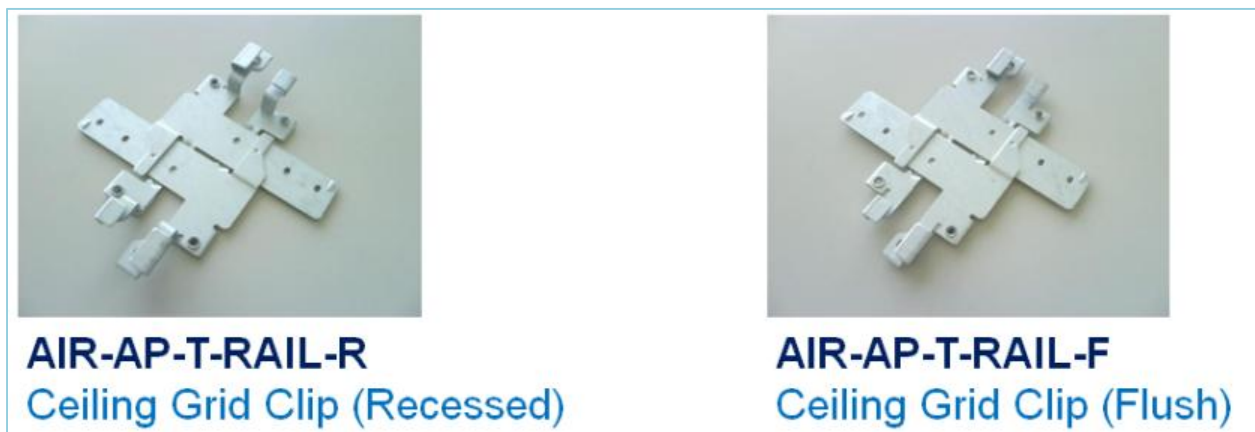
Figure 16: Recessed and Flushed Ceiling Grid Clips

If the AP needs to be mounted to an electrical box, to another type of wiring fixture, inside a NEMA enclosure or on a wall, the AIR-AP-BRACKET-2 is a better choice. The extra space in the bracket allows for wiring, and the extra holes line up with many popular electrical boxes.

## Channel Rail Adapters

When mounting APs to ceiling channel rails, such as those shown in Figure 17, use the optional channel adapter. The AIR-CHNL-ADAPTER comes in a two-pack, slides onto the channel rails, and attaches to the ceiling grid clips described above. Figures 18 and 19 show the channel rails, channel adapter, ceiling grid clip, and finished installation.

Figure 17: Channel Rails


Figure 18: AIR-CHNL-ADAPTER (left); Channel Rails (right)
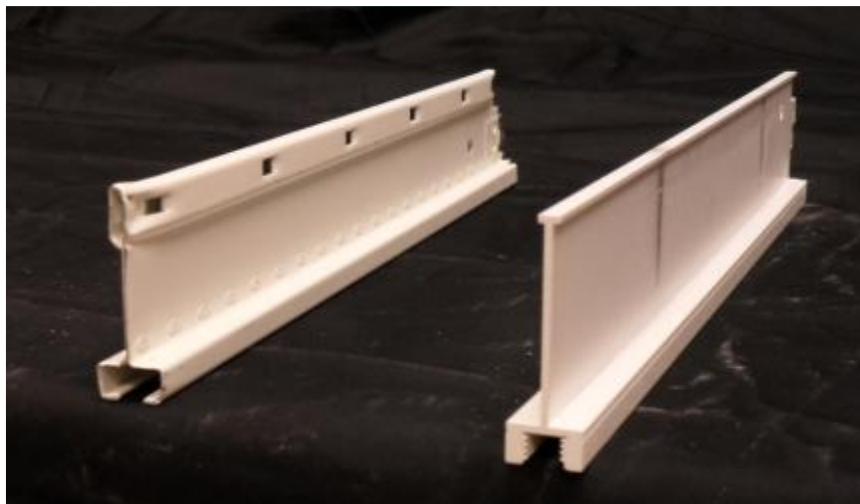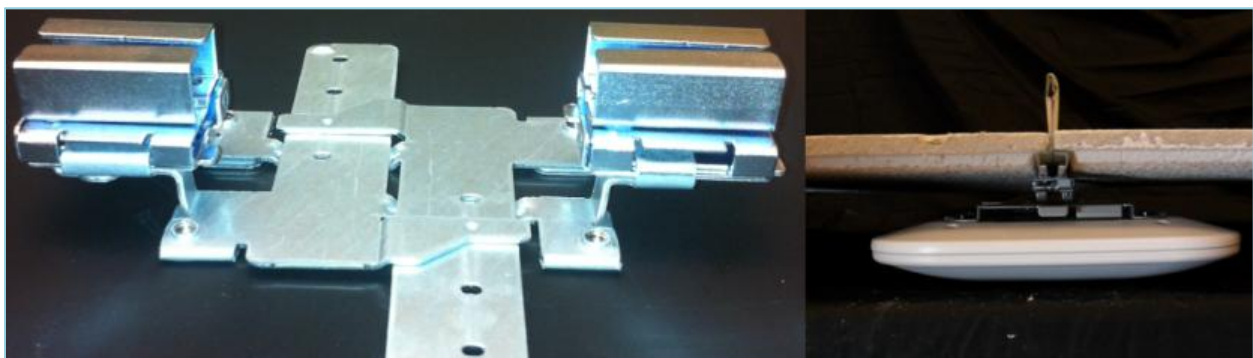

Figure 19: AIR-CHNL-ADAPTER and Ceiling Grid Clip (left); Finished Installation (right)

## Installation in Ceiling Tiles

Many hospitals and other carpeted enterprise environments prefer a more streamlined look and wish to install the AP directly into the tile. In this case, use the optional Cisco AIR-AP-BRACKET-3, as shown in Figure 20.

Figure 20: Optional AIR-AP-BRACKET-3 for Installation of APs into Ceiling Tiles

Use the "beauty ring" as a template to cut the tile. Cisco does not offer custom cut tiles but the tiles are easy to cut with a carpet knife or electric tool such as the Dremel™ or Rotozip™ rotary cutting tool.

A metal rail that extends the length of the tile supports the AP above the ceiling if the tile becomes wet or otherwise fails. A mechanical set screw pulls the AP tight to the ceiling and locks it into the bracket. Additionally, a Kensington style lock can be used for physical security of the AP, but, once installed, it is difficult to remove the AP without removing the tile since the AP does not slide out from the front side of the tile.

**Note**: This bracket fits the AP 1040, 1140, 1260, 1600, 2600, 3500, and 3600.

## Installation on Walls

Walls can be a physical obstacle to the wireless signal and may compromise 360 degree coverage. If the wall is an outside wall or if the goal is to send the signal in a 180-degree pattern rather than a 360-degree pattern, a directional antenna (often referred to as a patch antenna) used with the AP 3600e may be a better choice.

Avoid wall-mounting APs with internal antennas such as the AP 3600i. The internal antenna model is designed to mount to a ceiling to provide 360-degree coverage. If wall-mounted in a non-horizontal orientation, the signal may penetrate floors and ceilings. This causes unintended coverage and may result in additional, needless roaming access when, for example, a user with Wi-Fi phone walks on an adjacent floor.

Instead of wall-mounting APs with internal antennas, you can:

- Use the AP 3600e with dipoles or patch antennas.
- Use an optional wall mount bracket, such as the Oberon P/N 1029-00, that puts the AP 3600i or the AP 3500e into a horizontal orientation. (See Figure 21.) Use this Oberon bracket unless you have a hotspot, kiosk, or small venue scenario and roaming is not an issue.
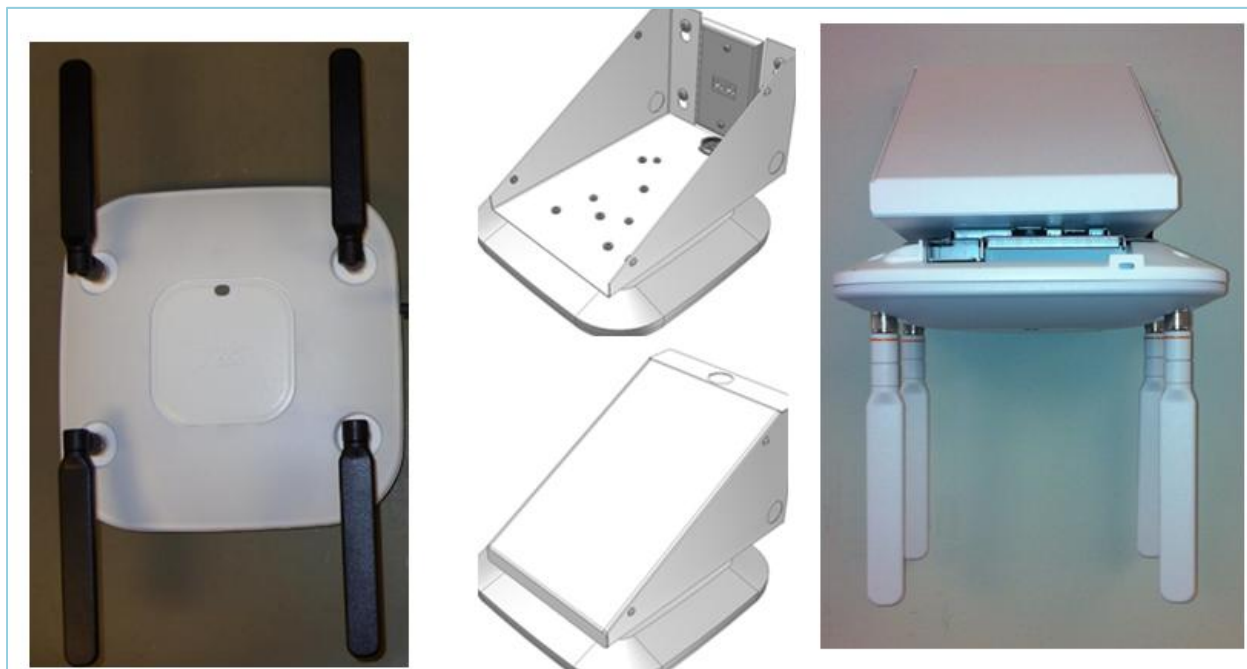


Figure 21: Vertical (Up/Down) Antennas on a Wall-Mounted AP (Left); Oberon Wall Mount Bracket (Center, Right)

## Color

To change the color of an AP, use colored vinyl tape or purchase a colored plastic cover from Oberon (see Figure 22). The Oberon cover can also be used to hide the Cisco logo or hide the LED. Do not paint the AP, since that voids the warranty.

Figure 22: Oberon Skin

# Unique Installations

## Clean Rooms

Many hospitals and factories have requirements to wipe down or gently spray the environment with a chemical (often diluted material that has cleaning and disinfectant properties). The AP 3600 is ideal for these types of applications because it is designed with a purpose guild Wi-Fi chipset with enterprise and industrial class components. This design enables the AP enclosure to have a Plenum rating and to be ventless. (See Figure 23.)
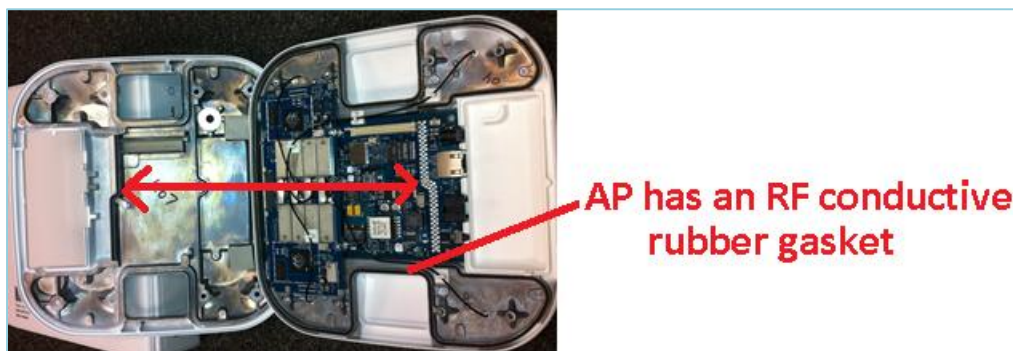


Figure 23: AP 3600 Industrial Class Components

**Note**: The AP 2600 is made of a similar construction and design for clean room deployments

If the clean room environment requires metal ceilings or areas where tile is not practical, a metal enclosure from Oberon can be used to protect and secure the AP. (See Figure 24.)

Figure 24: Oberon Metal Enclosure

## Above Ceiling Tiles

The AP 2600 and the AP 3600 are rated for installation in the Plenum area (UL-243). Many customers prefer to install the AP above a drop ceiling for aesthetic reasons, so that nothing is visible on the ceiling. This type of installation may also be appropriate in high theft areas such as classrooms or areas where policy dictates that nothing can be visible on the ceiling.

T-Bar hangar accessories, such as The Erico Caddy 512a or the Cooper B-Line BA50a, can be used for such installations. (See Figure 25.)
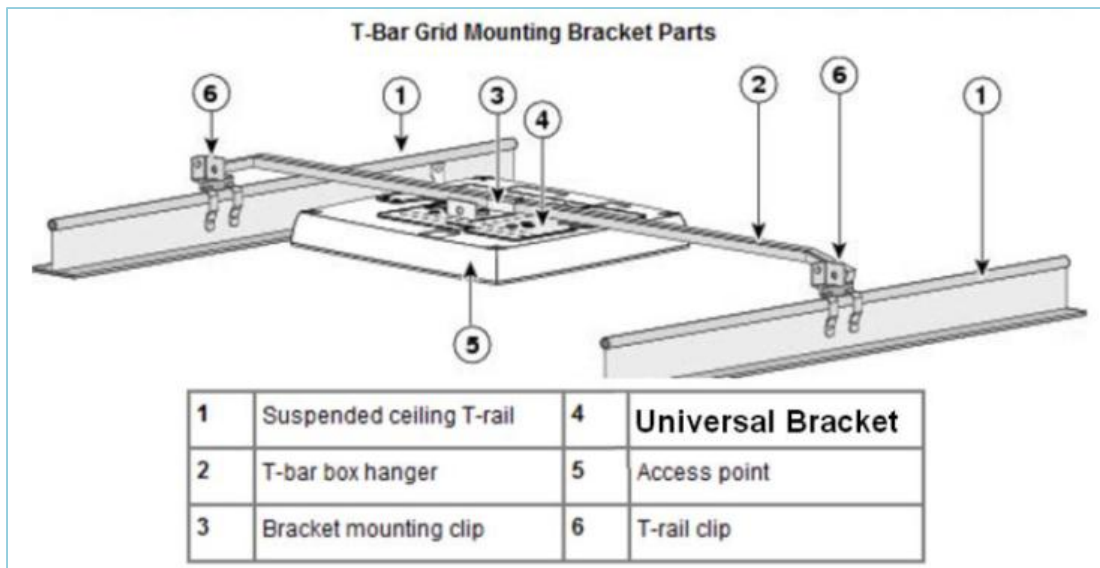
Figure 25: Installation of an AP Above Ceiling Tiles

**Note**: Install APs above the ceiling tiles **only** when mounting below the ceiling is not an option. "Above ceiling tiles" installations can certainly degrade advanced RF features such as voice and location, so verify coverage and performance and ensure the tiles are not conductive. Mount the AP as close to the inside middle of the tile as possible, and avoid areas with obstructions and clutter. (See Figure 26.)
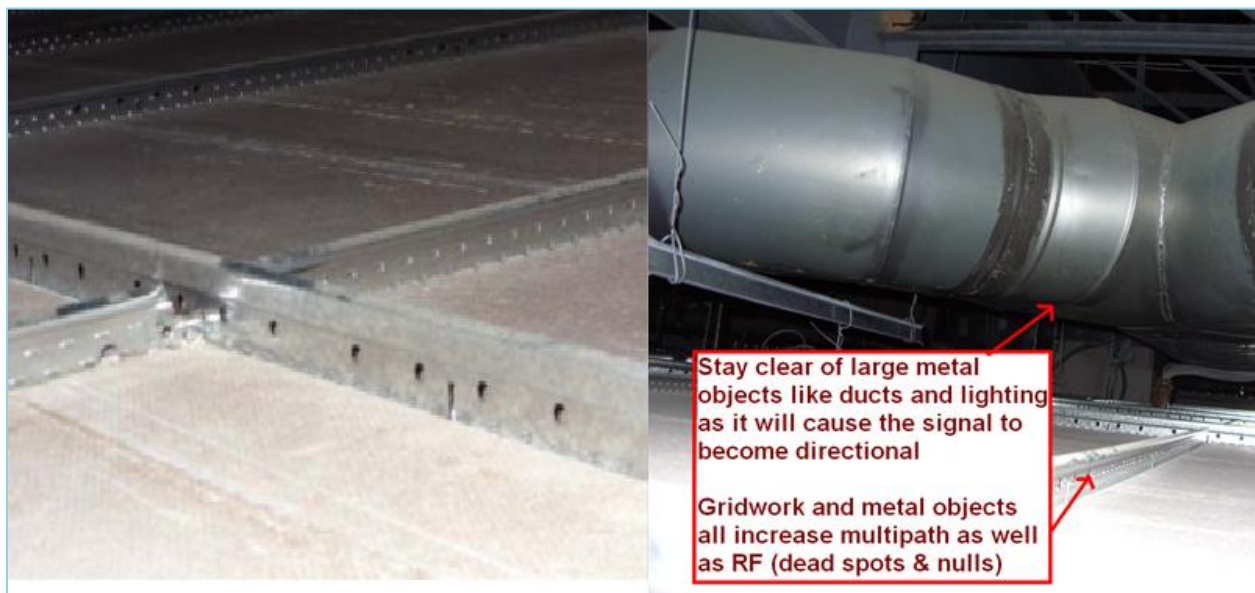


Figure 26: Placement of an AP Installation Above Ceiling Tiles

## Stadium and Harsh Environments

Customers may wish to use a NEMA type enclosure to install an AP in harsh environments where the AP may be exposed to weather, such as sporting areas, stadiums, open garden areas or warehouse freezers. There are several third-party sources for NEMA type enclosures.

**Note**: Some APs may not be certified for outdoor deployments in a NEMA enclosure. For example, in some areas of the world, regulatory agencies may permit AP outdoor NEMA enclosures if the AP is indoors (such as a freezer or garden area) but may prohibit use of those NEMA enclosures outdoors. This seems to vary with weather radar compliance, UNII-1 compliance, and so forth. Check with your local Cisco account team or the communications regulatory agency for your area.

Cables should exit from the bottom of the NEMA type enclosure so that rain and moisture do not run down the cable into the enclosure. The color of the enclosure may affect the heat rating; for example, a black enclosure gets much hotter in the sun than a white one. You may also want to use a pressure vent to prevent moisture accumulation. (See Figure 27.)
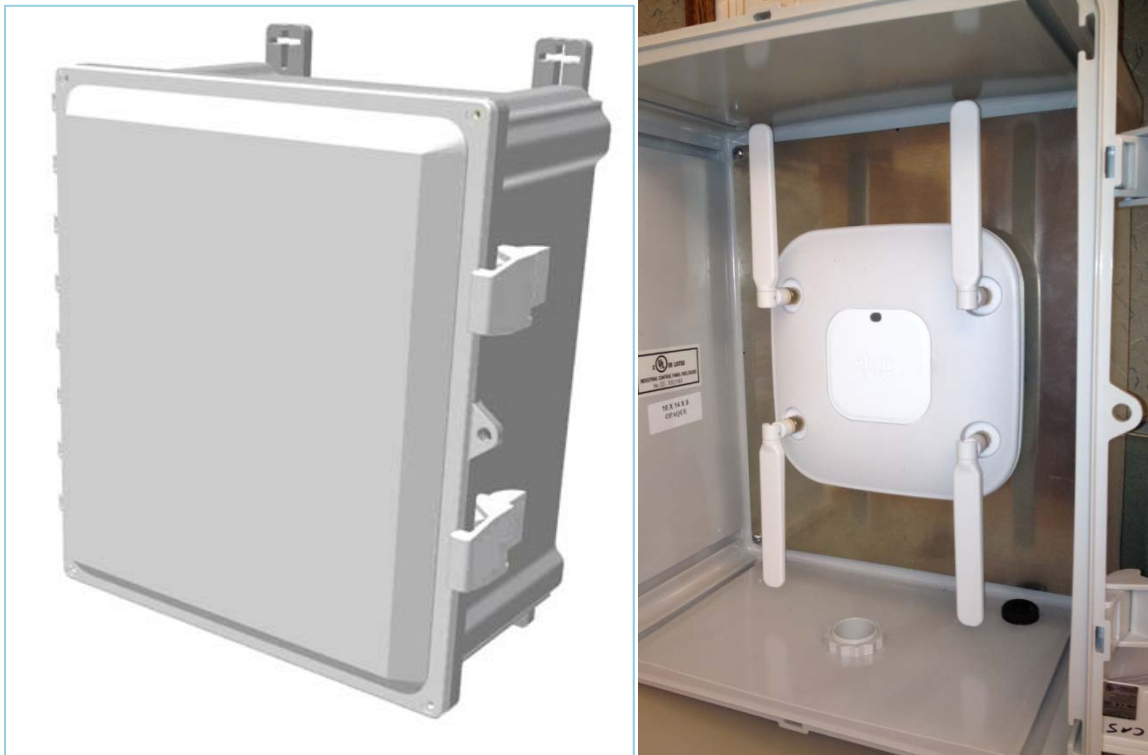


Figure 27: NEMA 16 x 14 x 8 Enclosure with Pressure Vent on Bottom

## Areas with High Vibration

If the access point is installed with a "side arm" type mount or is installed in locations where there may be high vibration, use a padlock or metal pin to secure the AP so it does not loosen or fall off the bracket. (See Figure 28.) McMaster offers a suitable pin (P/N 90319A120). Avoid use of plastic ties, which deteriorate over time.
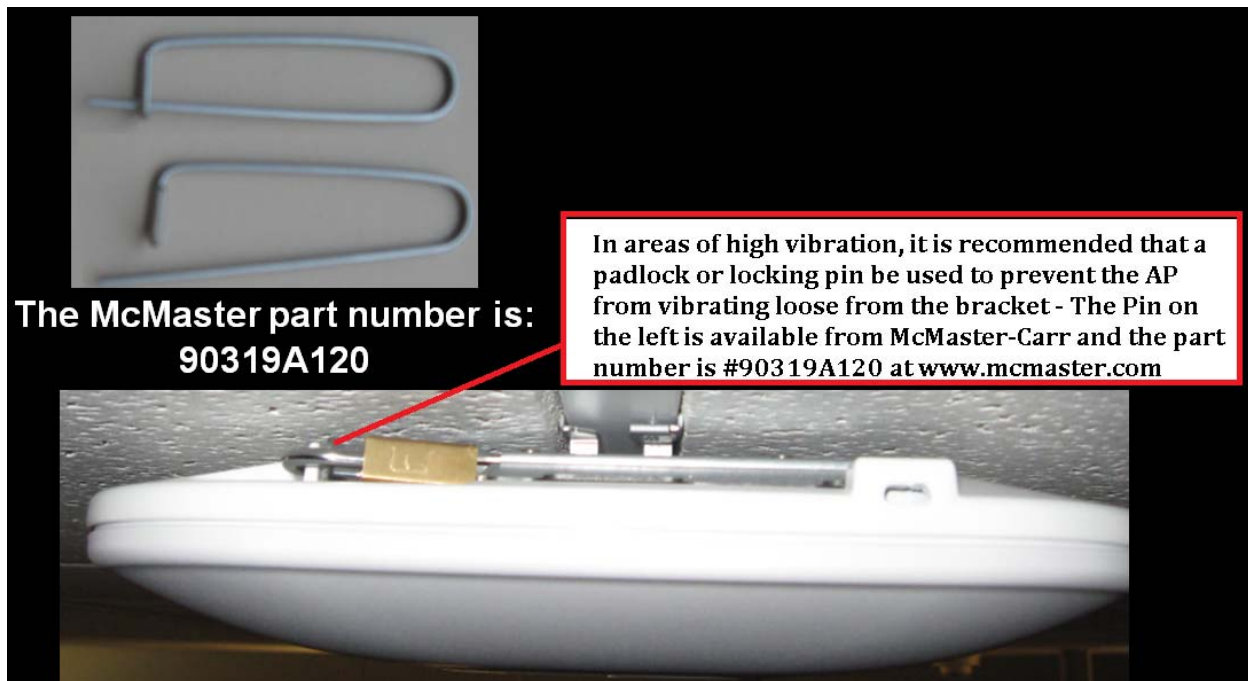
Figure 28: Metal Pins or Padlocks for Areas of High Vibration

## Warehouse and Factory

Warehouse installations are often difficult because of the very high ceilings and the clutter of the material in storage. As part of your site survey, always check the coverage when the warehouse is fully stocked, since the material in storage can change the RF coverage and interfere with uniform coverage.

For aisles, use directional (patch) antennas on the wall and shoot down the aisles. You can also use low-gain omnidirectional antennas (such as dipoles) on the ceiling or units with integrated antennas; high gain omnidirectional antennas tend to have more nulls. (See Figure 50.)

The higher the AP is mounted, the farther the signal must travel. Use pipe and electrical box mounting techniques to lower the AP (external and internal antenna models) so that it is closer to users. (See Figure 29.)

Figure 29: AP Placement in Warehouse

To mount an AP at the end of a pipe or electrical conduit box, use the universal bracket Cisco AIR-AP-BRACKET-2, because it mates to the holes of most electrical boxes. (See Figure 30.) Conduit and adapters are available at most electrical or home repair centers.

Figure 30: Installation of an AP onto an Electrical Conduit Box

**Ethernet Cable Recommendation**

While the AP 1600/2600 and the AP 3600 work well with CAT-5e for new cable installations, Cisco recommends that customers use CAT6a because CAT6a cable is required by the 10GE standard.

**Antenna Cable Recommendation**

Keep antenna cable runs as short as possible. Cisco offers low loss (LL) and ultralow loss (ULL) cables, which have the same characteristics as Times Microwave LMR-400 and LMR-600.

**Note**: When drilling holes for cable, allow for the size of connector drill bit, which is typically 5/8". (See Figure 31.)


Figure 31: Cable Installation, with Allowance for Connector

Cisco cables carry the part number AIR-CAB (Aironet Cable) and then a length. For example, a 20' length of LL cable with RP-TNC connector is Cisco AIR-CAB-020LL-R. These heavy black cables are not Plenum rated and are primarily for use outdoors or in manufacturing areas.

**Access Point Spacing Recommendations**

If you have a Wi-Fi device such as an AP and want to use another AP in the vicinity on a different channel, space the APs approximately six feet (two meters) apart. This recommended distance is based on the assumption that both devices operate in the unlicensed band and do not transmit RF energy more than 23 dB - that is, 200 mW. If higher power is used, space farther apart. Avoid clustering the APs or the antennas from different APs together, since this could degrade performance.

If you have other devices that transmit, move or separate the devices as far apart as reasonable. (This is especially important if they operate in the same frequency ranges; for example, frequency hopping legacy APs or other devices may operate just below or above the 2.4 and 5 GHz band.) Then, check for interference. Test both types of devices at the same time under heavy utilization (load), then characterize each system independently to see whether degradation exists.

**Warning**: In order to comply with FCC, EU, and EFTA RF exposure limits, antennas should be located at a minimum of 7.9 inches (20 cm) or more from the body of all persons. See the installation guide under Declaration of Conformity for more information.

## IDF Closets (Telecommunications or Other Electrical Equipment)

When installing APs near other electrical or telecommunications equipment, keep all wiring and metal away from the antennas, and avoid placing the antennas near electrical lines. Do not route electrical wiring or Ethernet in the near field (6-15 inches) of the antenna, and try not to install the AP in an electrical closet. If you remote antenna cables from such a closet, you may be required to use Plenum rated cable, so refer to local fire and safety regulations. Remember that the best place for the AP is as close to the users as practical.

For more information on interference, see these URLs:

* http://www.cisco.com/en/US/prod/collateral/wireless/ps9391/ps9393/ps9394/prod_white_paper0900aecd807395a9_ns736_Networking_Solutions_White_Paper.html
* http://www.cisco.com/warp/public/cc/pd/witc/ao1200ap/prodlit/wrlan_wp.pdf
* http://www.cisco.com/en/US/prod/collateral/wireless/ps5678/ps10981/white_paper_c11-609300.html

## Very High Altitudes

While not defined in the specification sheet for the AP 2600 and the AP 3600, these APs passed functional checks after a non-operational altitude test of 25C @ 15,000 Ft was performed. Additionally, they fully passed a functional test during an operational altitude test of 40C @ 9,843 ft.

All units in the test group were connected to at least one WLAN client and were monitored for continual operation passing traffic, with constant ping testing throughout the operational altitude test.

## Common or Distributed Antenna System (DAS)

Due to the dual-band nature of the antenna system on the AP 2600 and the AP 3600, along with key features such as ClientLink 2.0 beamforming, the AP 2600 and the AP 3600 are not recommended for deployments on Distributed Antenna Systems (DAS).

**Note**: **Cisco does not certify, endorse or provide** RF support for Wi-Fi deployments over any DAS.

The DAS vendor and systems integrator are solely responsible for the support of the DAS products, adequate RF coverage, and any RF-related issues. This support includes, but is not exclusive to, location accuracy, RF coverage, roaming issues related to RF, multipath issues, and scalability.

The DAS vendor and systems integrator are also responsible for understanding that the deployed DAS system meets the requirements of all of the customer Wi-Fi devices and applications over the DAS system; this statement includes, but is not exclusive to, all Voice over WLAN (VoWLAN) and medical devices.

While Cisco Technical Assistance Center (TAC) and Cisco field teams do not provide support for RF issues that arise in a Cisco WLAN used over a DAS, they do provide support for non-RF related issues in Cisco products according to the customer support agreement with Cisco Systems.

For more information, see the following URL:

http://www.cisco.com/en/US/prod/collateral/wireless/ps5678/ps6973/positioning_statement_c07-565470_ps10092_Products_Data_Sheet.html

## Elevators

Elevator coverage can sometimes be accomplished by placing APs in the near field of the elevator, typically on each floor near the elevator door. Since elevators often have metal doors, and the shafts are often concrete or contain other materials that degrade Wi-Fi coverage, it is important to check the coverage inside the elevator. Elevator coverage can be a challenge, but it is often possible, especially if the elevator only serves a few floors.

In high rise elevators, roaming issues are more problematic because the client cycles through a large number of APs rather quickly. Some companies put a patch antenna on the floor inside the shaft and a patch antenna on the bottom of the elevator car, while other companies use leaky coaxial cable along the side of the shaft.

When installing any Wi-Fi equipment inside elevator cars or shafts, follow local regulations. Some installations may be prohibited because of safety reasons, while other installations may be prohibited by the building owner or local fire department. Only elevator repair persons or experienced contractors should perform this type of work.

# External Antenna Options and Patterns

## AP 1600/2600 and AP 3600e

The following dual-band, dual-resonant antennas are available for use with the AP 1600e*/2600e and the AP 3600e:

AIR-ANT2524DB-R   –   Dual-band (Black) dipole     (4 required) –   2/4 dBi Dipole
AIR-ANT2524DW-R   –   Dual-band (White) dipole    (4 required) –   2/4 dBi Dipole
AIR-ANT2524DG-R   –   Dual-band (Grey) dipole     (4 required) –   2/4 dBi Dipole
AIR-ANT2524V4C-R   –   Dual-band Omni-directional (1 required) –   2/4 dBi Ceiling mount Omni use
AIR-ANT2544V4M-R   –   Dual-band Omni-directional (1 required) –   4/4 dBi Wall mount Omni use
AIR-ANT2566P4W-R   –   Dual band directional        (1 required) –   6 dBi Patch wall mount use

*The AP 1600 requires only three dipole antennas, not four. For ceiling, wall or patch mounts, simply leave the fourth antenna lead unused.

Do not use single-band antennas unless you choose to disable the other radio band in the AP.

For details on all Cisco antennas, see the Cisco Antenna Reference Guide at this URL:

www.cisco.com/go/antenna-ref

You can also individual datasheets at this URL:

http://www.cisco.com/en/US/products/hw/wireless/ps469/index.html

The two most popular external antennas for the AP 3600e are the AIR-ANT2524Dx-R dual-band dipole antenna (see Figures 32 and 33) and the AIR-ANT2566P4W-R dual-band patch antenna (see Figures 34 and 35). Other antennas include the AIR-ANT2524V4C-R (see Figures 36 and 37) and the AIR-ANT2544V4M-R (see Figures 38 and 39).

## Technical Specifications

| Parameter | Specification |
|---|---|
| Antenna type | Dual-band dipole |
| Operating frequency range | 2400 to 2500 MHz |
| | 5150 to 5850 MHz |
| Nominal input impedance | 50Ω |
| VSWR | Less than 2:1 |
| Peak Gain @ 2.4. GHz | 2 dBi |
| Peak Gain @ 5 GHz | 4 dBi |
| Elevation plane 3dB beamwidth @2.4 GHz | 63 degrees |
| Elevation plane 3dB beamwidth @ 5 GHz | 39 degrees |
| Connector type | RP-TNC plug |
| Antenna length | 6.63 in. (168.5 mm) |
| Antenna width | 0.83 in (21 mm) |
| Radome length | 4.88 in. (124 mm) |
| Weight | 1.3 oz |
| Operating temperature | –20°C to 60°C (–4° to 140°F) |
| Storage temperature | –40°C to 85°C (–40°F to 185°F) |
| Environment | Indoor, office |

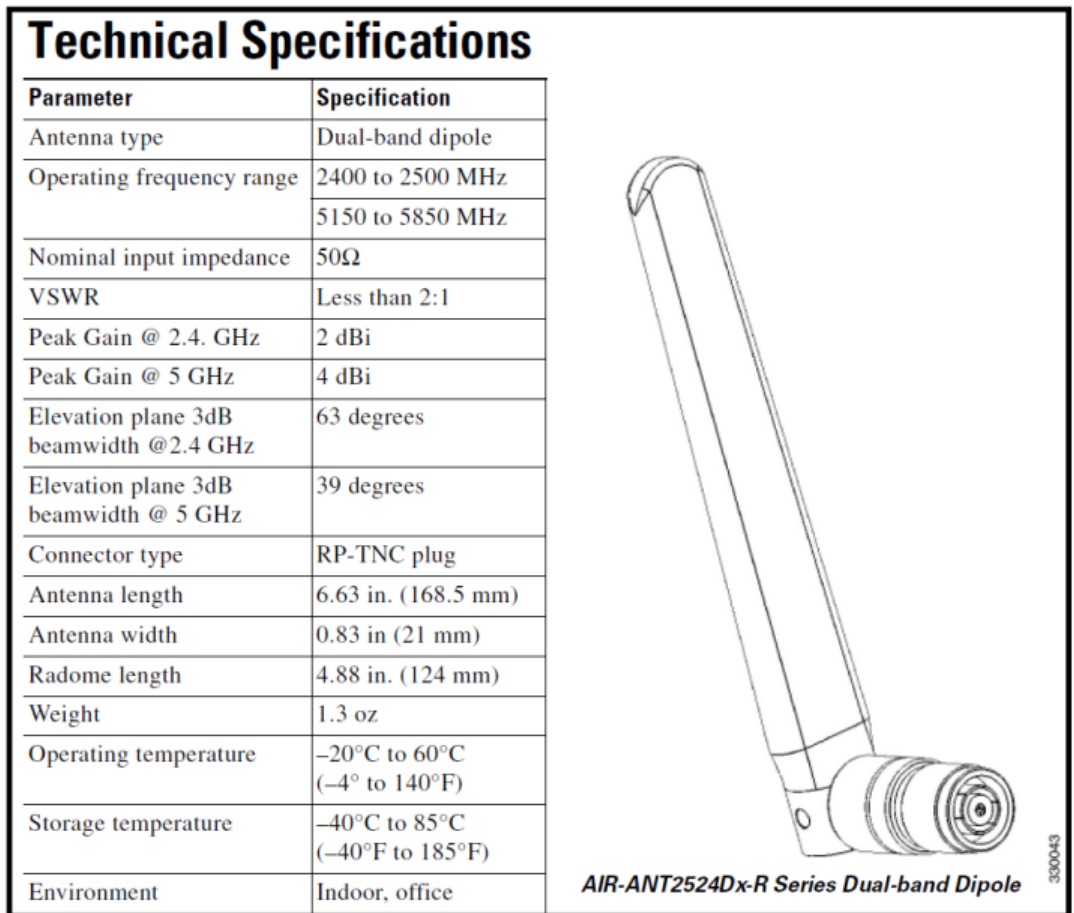*AIR-ANT2524Dx-R Series Dual-band Dipole*

Figure 32: Specifications for the AIR-ANT2524Dx-R Dual-Band Dipole Antenna
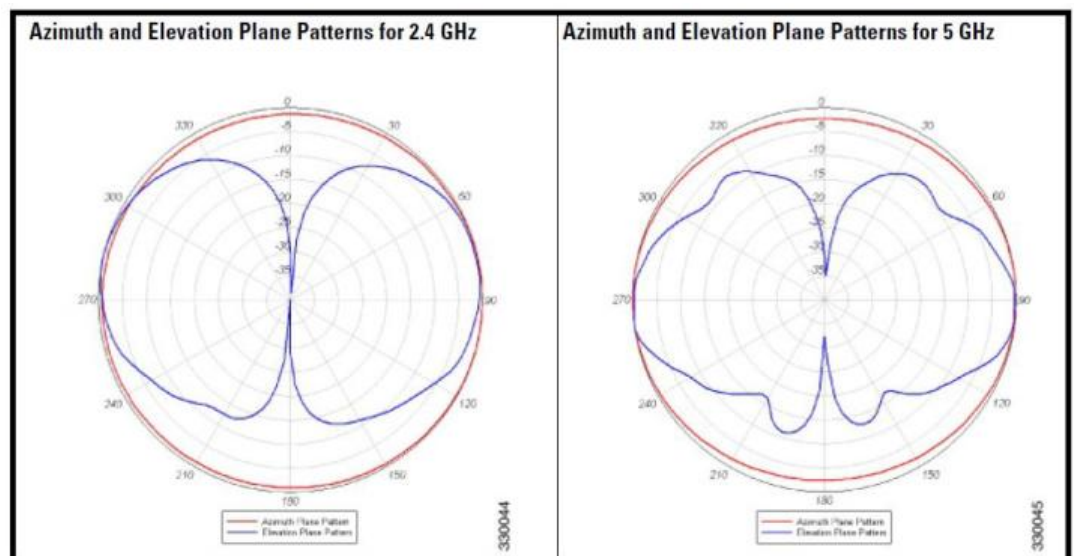
Figure 33: Radiation Pattern for the AIR-ANT2524Dx-R Dual-Band Dipole Antenna
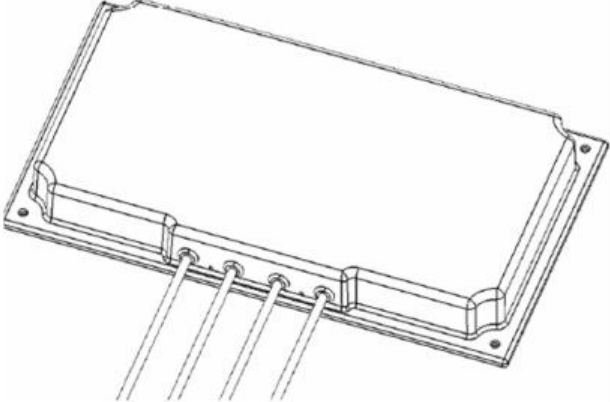
| | |
|---|---|
| Antenna type | 4-element dual-band MIMO |
| Operating frequency range | 2400 to 2484 MHz |
| | 5150–5850 MHz |
| VSWR | 2:1 or less |
| Gain | 6 dBi in both bands |
| Polarization | Linear, vertical |
| Azimuth Plane 3-dB Beamwidth | 2.4 GHz band: 105° |
| | 5 GHz band: 125° |
| Elevation Plane 3-dB Beamwidth | 2.4 GHz band: 70° |
| | 5 GHz band: 60° |
| Length | 6.3 in. (16 cm) |
| Width | 11 in. (27.9 cm) |
| Depth | 1.2 in. (3.05 cm) |
| Weight | 1.4 lbs |
| Cable length and type | 3 ft. (91.4 cm) plenum rated |
| Connector | RP-TNC |
| Environment | Indoor/outdoor |
| Operating temperature range | -22° to 158° F |
| | -30° to 70° C |

**AIR-ANT2566P4W-R
4 Element Dual-Band Patch
(indoor / outdoor use)**

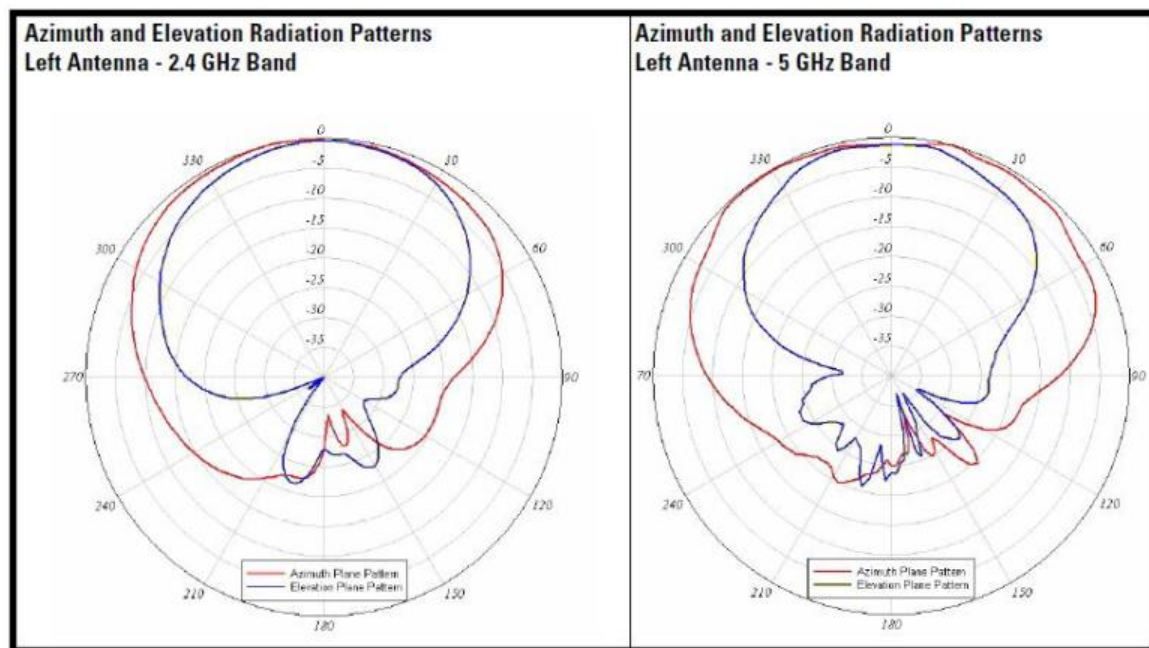Figure 34: Specifications for the AIR-ANT2566P4W-R Dual-Band Patch Antenna



Figure 35: Radiation Pattern for the AIR-ANT2566P4W-R Dual-Band Patch Antenna

If the antenna is mounted on a wall, the azimuth (in red) is the signal going forward from the antenna, and the elevation (in blue) is the up/down pattern.

| Antenna type | 4-Element, Dual-band, Low Profile Omni |  |
|---|---|---|
| Operating frequency ranges | 2400–2484 MHz 5150–5850 MHz | |
| VSWR | 2:1 or less in both bands | |
| Peak gain | 2.4-GHz band: 2 dBi 5-GHz band: 4 dBi | |
| Polarization | Linear | |
| Azimuth plane 3 dB beamwidth | Omnidirectional | |
| Elevation plane 3 dB beamwidth | 2.4-GHz band: 69° 5-GHz band: 60° | |
| Length | 7.25 in (18.4 cm) | |
| Width | 7.25 in (18.4 cm) | |
| Depth | 1 in (2.5 cm) | |
| Weight | 1.3 lb (0.59 kg) | |
| Cable | 3 ft (91.4 cm) plenum rated, UV stable | |
| Connector | RP-TNC | |
| Environment | Indoor | |
| Temperature range | 32°F to 133°F (0°C to 56°C) | |

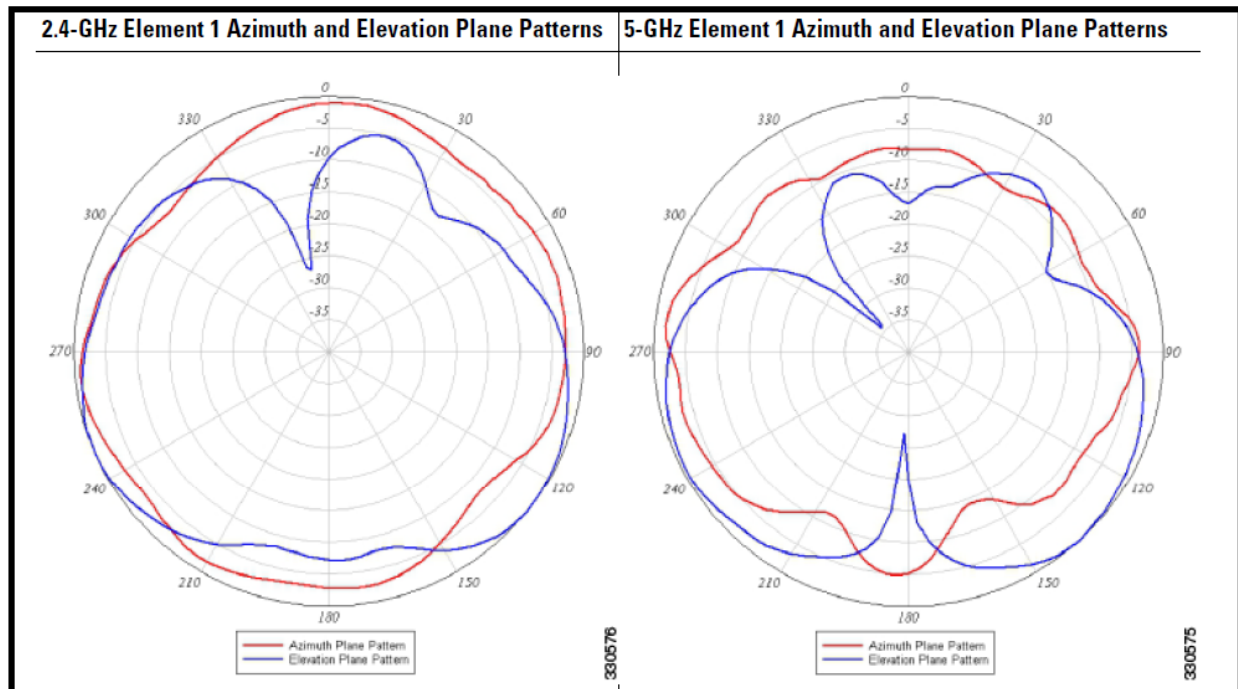Figure 36: Specifications for the AIR-ANT2524V4C-R Dual-Band Omni Antenna



Figure 37: Radiation Pattern for the AIR-ANT2524V4C-R Dual-Band Omni Antenna

| Antenna type | 4-element MIMO omnidirectional |
|---|---|
| Operating frequency range | 2400-2484 MHz |
| | 5150-5850 MHz |
| Nominal input impedance | 50Ω |
| VSWR | 2:1 or less |
| Peak gain | 2.4-GHz band: 4 dBi |
| | 5-GHz band: 4 dBi |
| Polarization | Linear, vertical |
| Azimuth plane (3 dB beamwidth) | Ominidirectional |
| Elevation plane (3 dB beamwidth | 2.4-GHz band: 60° |
| | 5-GHz band: 33° |
| Length | 8.6 in (21.8 cm) |
| Diameter | 6.3 in (16 cm) |
| Weight | Antenna: 1.48 lb. (671.5 g); |
| Cable | 3-ft. (91.4 cm) plenum |
| Connector | RP-TNC |
| Environment | Indoor/outdoor |
| Temperature range | -22° F to 158° F (-30° C to 70° C) |

Figure 38: Specifications for the AIR-ANT2544V4M-R Dual-Band Omni Antenna
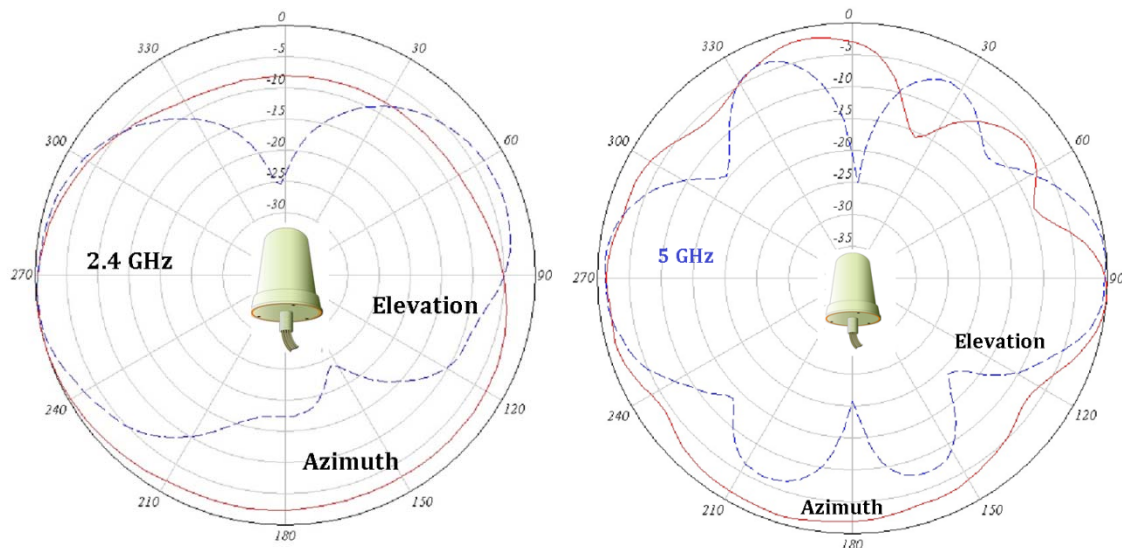


Figure 39: Radiation Patterns for the AIR-ANT2544V4M-R Dual-Band Omni Antenna
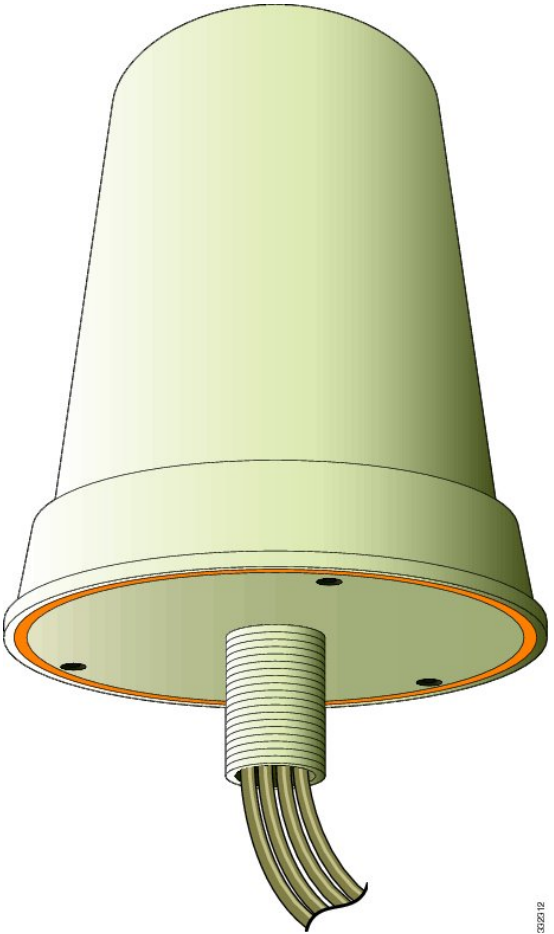
**Note**: For larger patterns, see the individual specification sheet for this antenna.

## AP 3600i, AP 2600i, and AP 1600i

Figures 40 and 41 show the radiation patterns for the AP 3600i (internal antenna model).
Figures 42 and 43 show the radiation patterns for the AP 2600i (internal antenna model).
Figures 44 and 45 show the radiation patterns for the AP 1600i (internal antenna model).
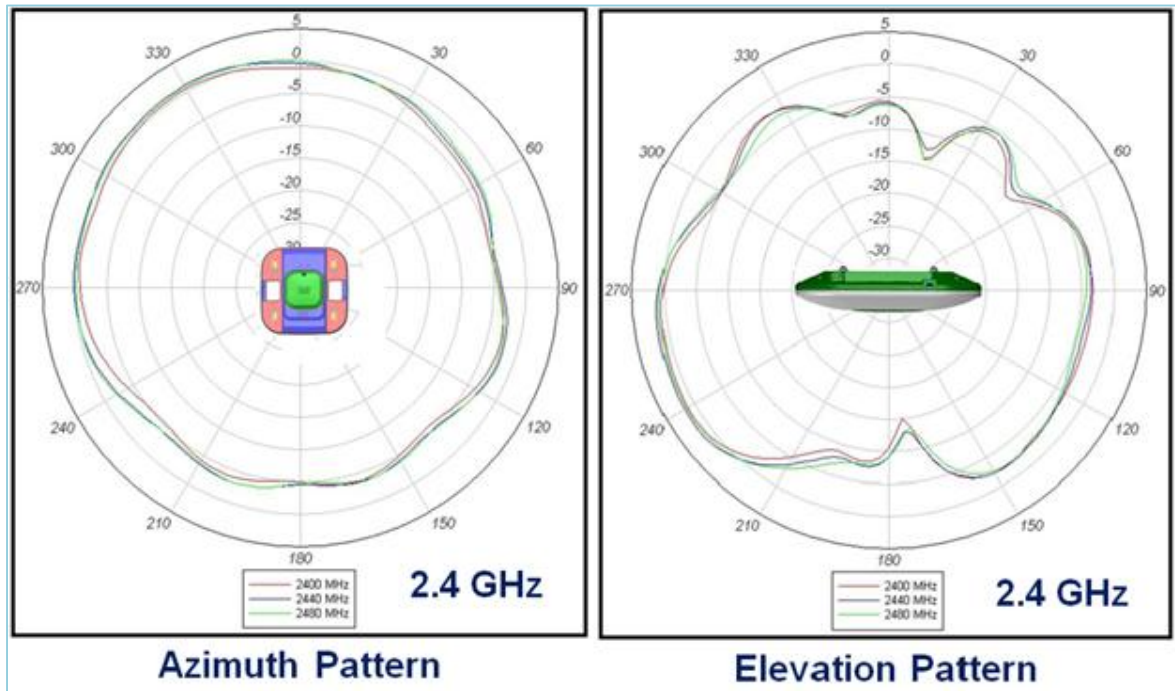


Figure 40: Radiation Patterns for the AP 3600i @ 2.4 GHz
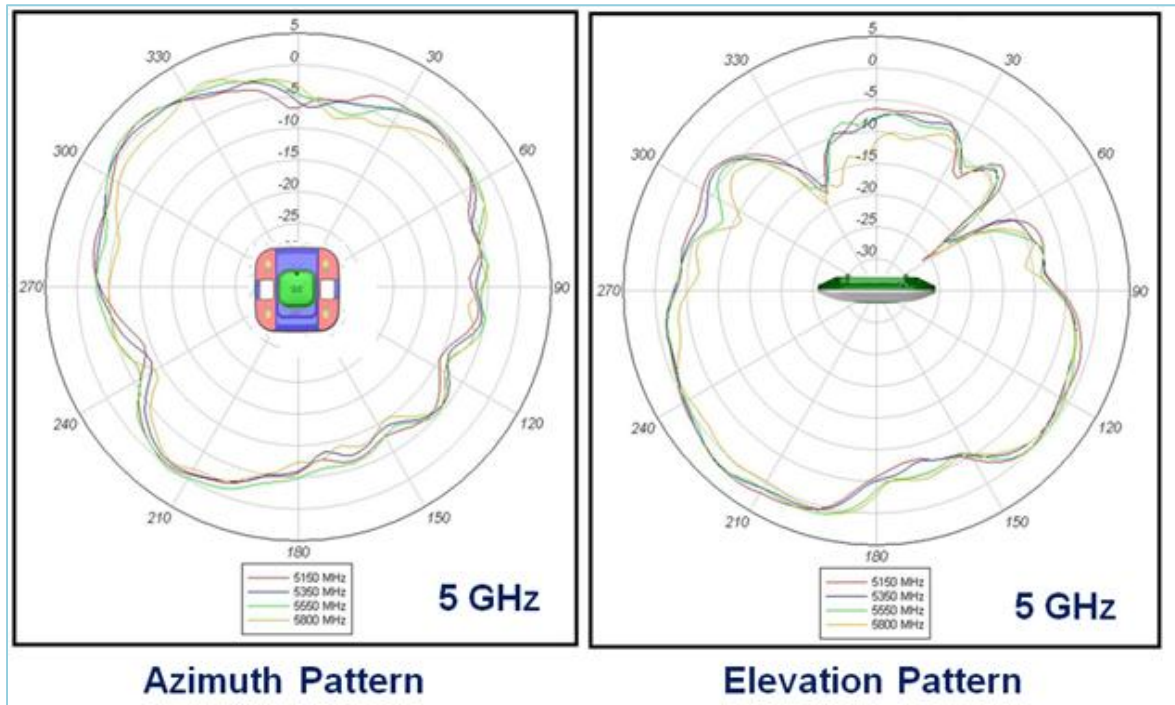


Figure 41: Radiation Patterns for the AP 3600i @ 5 GHz

## AP-2600i – Antenna Patterns 2.4 GHz



**Azimuth Plane 2.4 GHz**          **Elevation Plane 2.4 GHz**
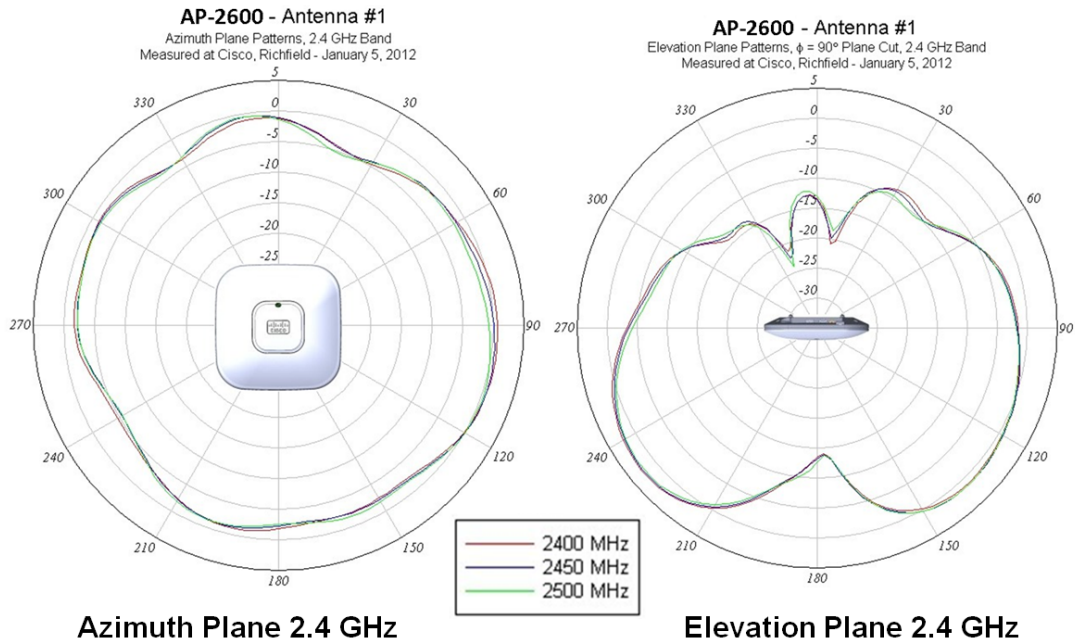
Figure 42: Radiation Patterns for the AP 2600i @ 2.4 GHz

## AP-2600i – Antenna Patterns 5 GHz



**Azimuth Plane 5 GHz**          **Elevation Plane 5 GHz**
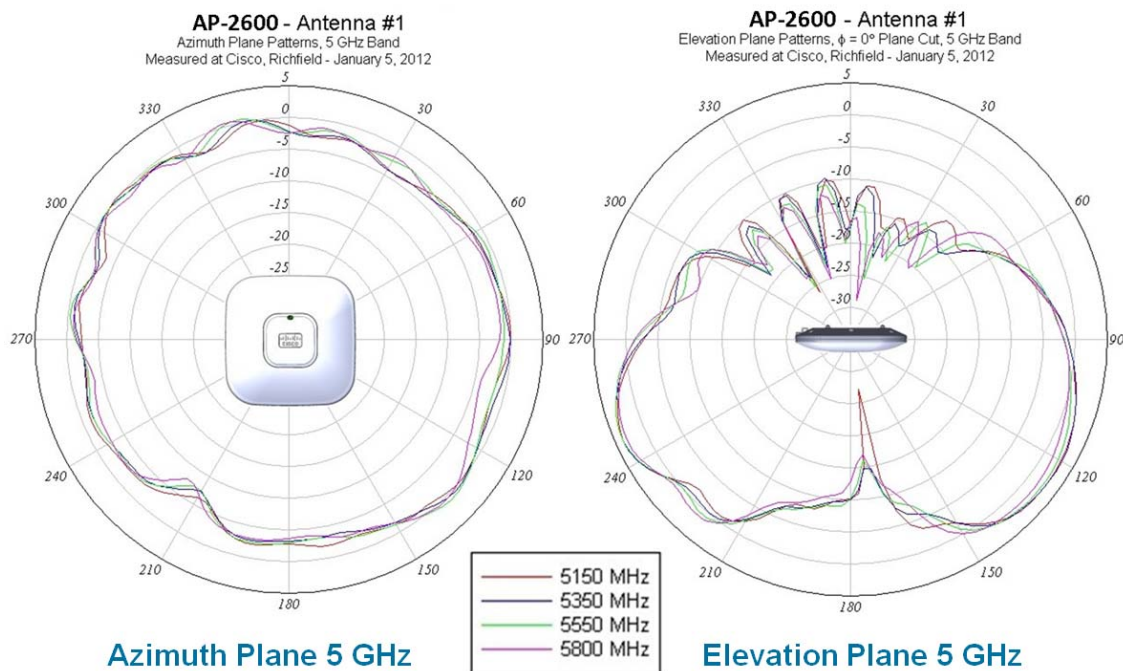
Figure 43: Radiation Patterns for the AP 2600i @ 5 GHz

## AP-1600 2.4 GHz antenna patterns

**AP-1600 Patterns - Ant #1**
Azimuth Plane Patterns, 2.4 GHz Band

2400 MHz
2450 MHz
2500 MHz

**AP-1600 Patterns - Ant #1**
Elevation Plane Patterns, φ = 0° Plane Cut, 2.4 GHz Band

2400 MHz
2450 MHz
2500 MHz

2.4 GHz Azimuth

2.4 GHz Elevation
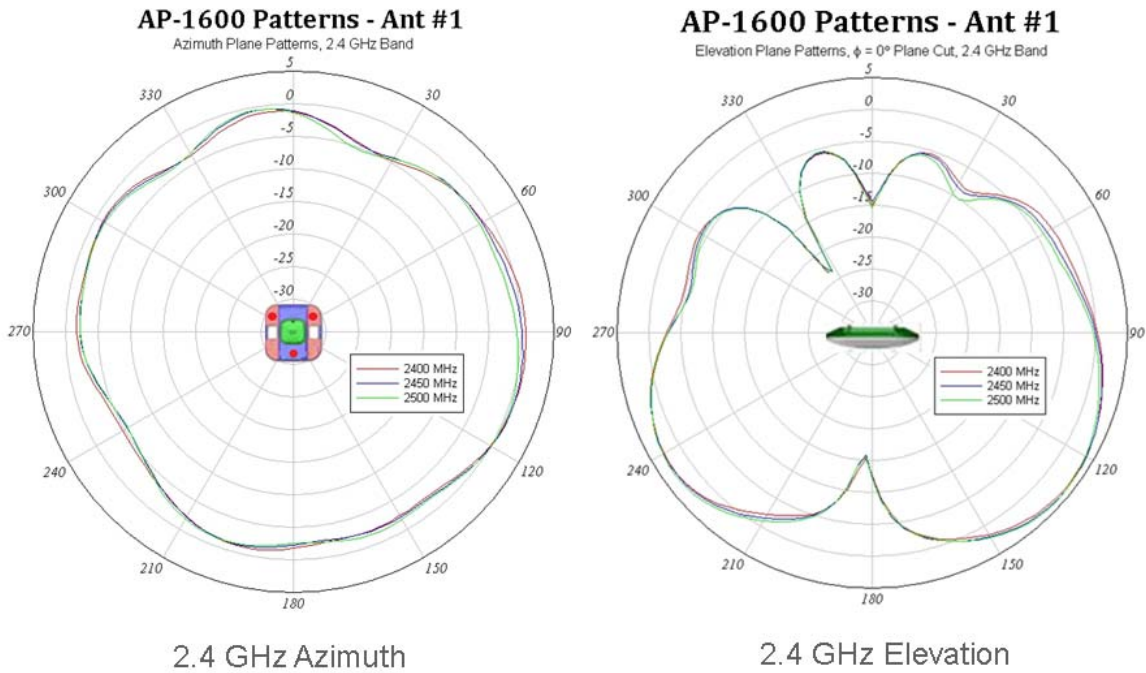
Figure 44: Radiation Patterns for the AP 1600i @ 2.4 GHz

## AP-1600 5 GHz antenna patterns

**AP-1600 Patterns - ANT #1**
Azimuth Plane Patterns, 5 GHz Band

5150 MHz
5350 MHz
5550 MHz
5800 MHz

**AP-1600 Patterns - ANT #1**
Elevation Plane Patterns, φ = 0° Plane Cut, 5 GHz Band

5150 MHz
5350 MHz
5550 MHz
5800 MHz

5 GHz Azimuth

5 GHz Elevation

Figure 45: Radiation Patterns for the AP 1600i @ 5 GHz

# External Antenna Deployments

All Cisco antenna connectors are labeled A, B, C, and so on. A has a higher priority than B, C, or D; therefore, if the access point supports say three or four antennas and you only have two antennas, use ports A and B until you could install the additional antennas.

It is possible to support 802.11a/b/g clients or single spatial stream N clients with only one or two antennas. Cisco does not recommend this because there is a significant degradation of performance, and ClientLink functionality is lost. If you choose to use fewer antennas, configure the access point in software to not use the other antennas.

**Note**: The entry-level AP 1600 has three antenna ports that are not configurable. The AP 2600/3600 has four configurable antenna ports, with one extra transceiver (receiver/transmitter) per band.
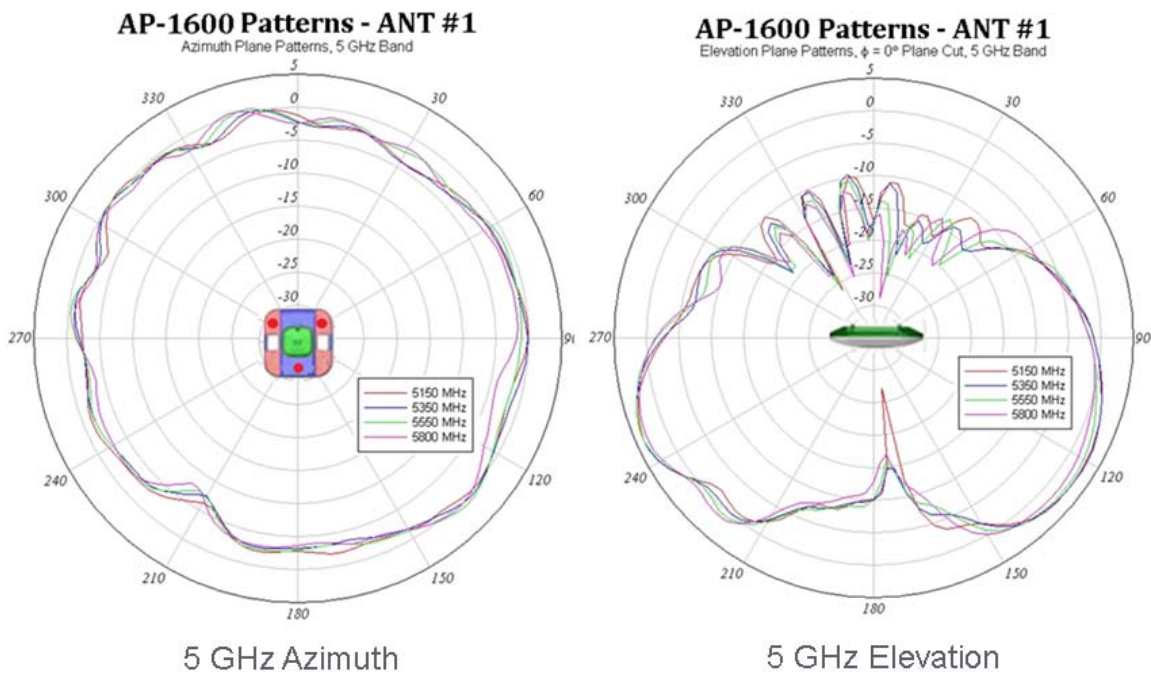
MIMOs (dual-radiating element antennas) include:

AIR-ANT2524V4C-R  –  Dual-band omnidirectional  –  2/4 dBi ceiling mount omni use
AIR-ANT2544V4M-R  –  Dual-band omnidirectional  –  4/4 dBi wall mount omni use
AIR-ANT2566P4W-R  –  Dual band directional  –  6 dBi patch wall mount use

For MIMOs, it is not critical which antenna lead goes into which antenna port on the access point, as long as all the antenna ports on the AP are connected to the antennas. The patch antenna AIR-ANT2566P4W-R has the elements spaced side by side in the plastic housing, so there is a slight improvement if you use the outer two elements on the patch on ports A and B (see Figure 46), but this is not critical. On the AP 1600, port A is spaced furthest from B and C for best diversity, as shown in Figure 47.


Figure 46: 6 dBi Patch Antenna

Figure 47: Port Spacing on the AP 1600

The best antenna placement is the one where the antenna is physically closest to the actual users. If you are mounting multiple, single package, dual-band antennas externally, such as dipoles, spacing is not critical. Try to space the antennas as far apart as practical (with A and B the furthest apart), but no further than 10' apart, since antennas should be in same RF coverage area. (See Figure 48.)


Figure 48: Antenna Placement

**Note**: Avoid using single-band (single-radiating element antennas) like those used with the earlier AP 3500, because they are not fully compatible with the newer AP 1600/2600 and AP 3600. Antennas for the AP 1260 and the AP 3500 are single-radiating element antennas made for each individual band. The AP 3600, 2600, and 1600 use dual-band, dual-radiating element antennas and are branded with an orange marking. (See Figures 46 and 47.)

When using 802.11n rates in areas with high metal, such as distribution areas or airport hangars, lower gain antennas on the ceiling may perform better because they tend to radiate the signal in all directions and increase the chance that multi-path will enhance the signal. If you have a clear path, a patch antenna at the end of an aisle at roughly the same height or just above the (WLAN client) is preferred. (See Figure 49.) Be sure to do a site survey.



Figure 49: Importance of Site Survey in Areas with High Amounts of Metal

A high gain antenna may have a null or dead spot directly below it because the antenna element is often much longer and has less metal surface area available to conduct the radio wave if you are directly underneath it. (See Figure 50.) The further away you are from the antenna, the more surface is available, and the better it performs.
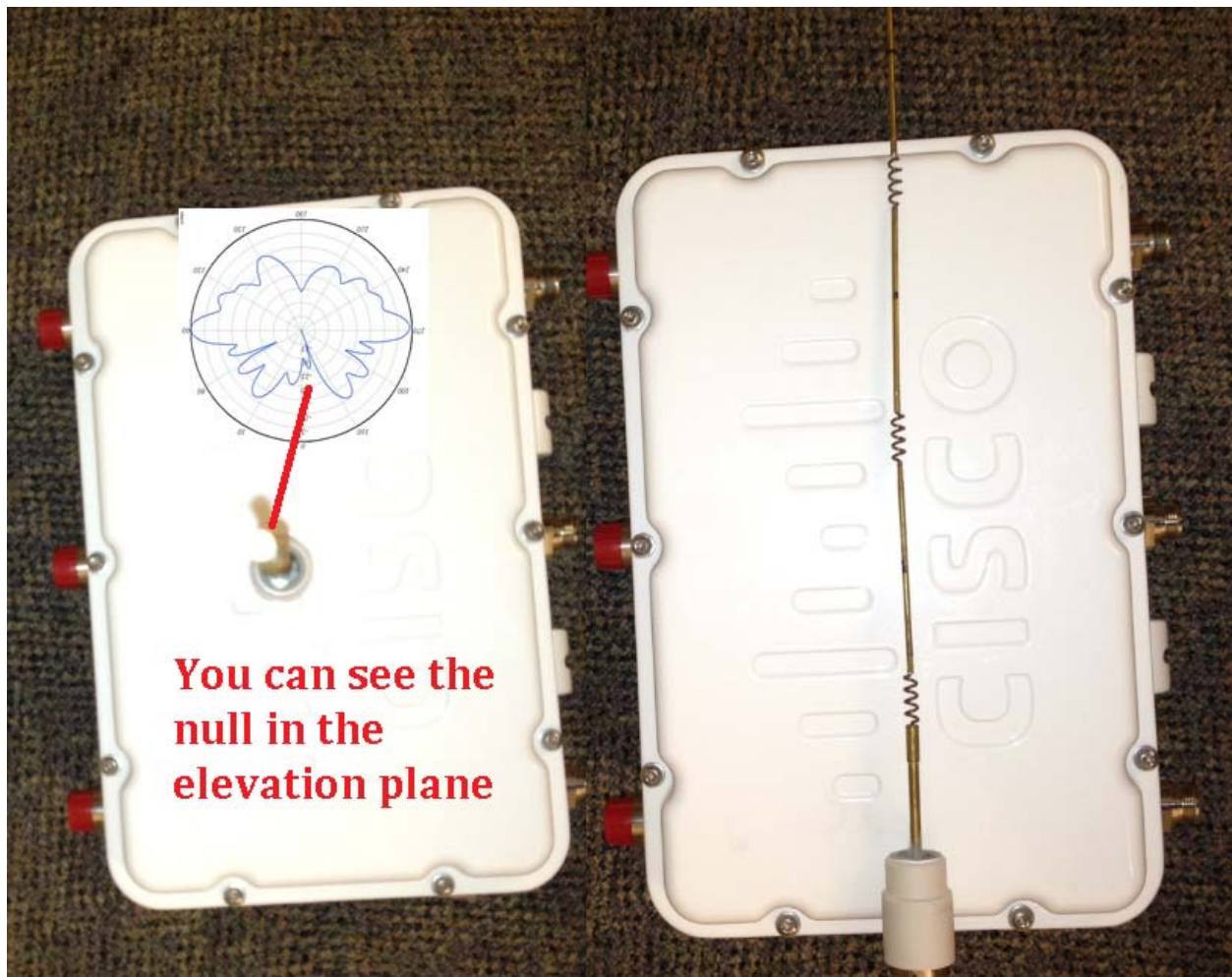
Figure 50: High Gain Antenna (AIR-ANT2480V-N) with Cover Removed

# 802.11n, Spatial Streams, and Beamforming

For a video on the fundamentals of spatial streams, see the following URL:

http://www.cisco.com/en/US/netsol/ns767/index.html

MIMO, which refers to a radio system that has multiple separate receive and transmit paths, is at the heart of 802.11n. MIMO systems are described by the number of transmitters and receivers in the system. For example, "two by one" or 2x1 refers to a system with two transmitters and one receiver. (See Figure 51.)
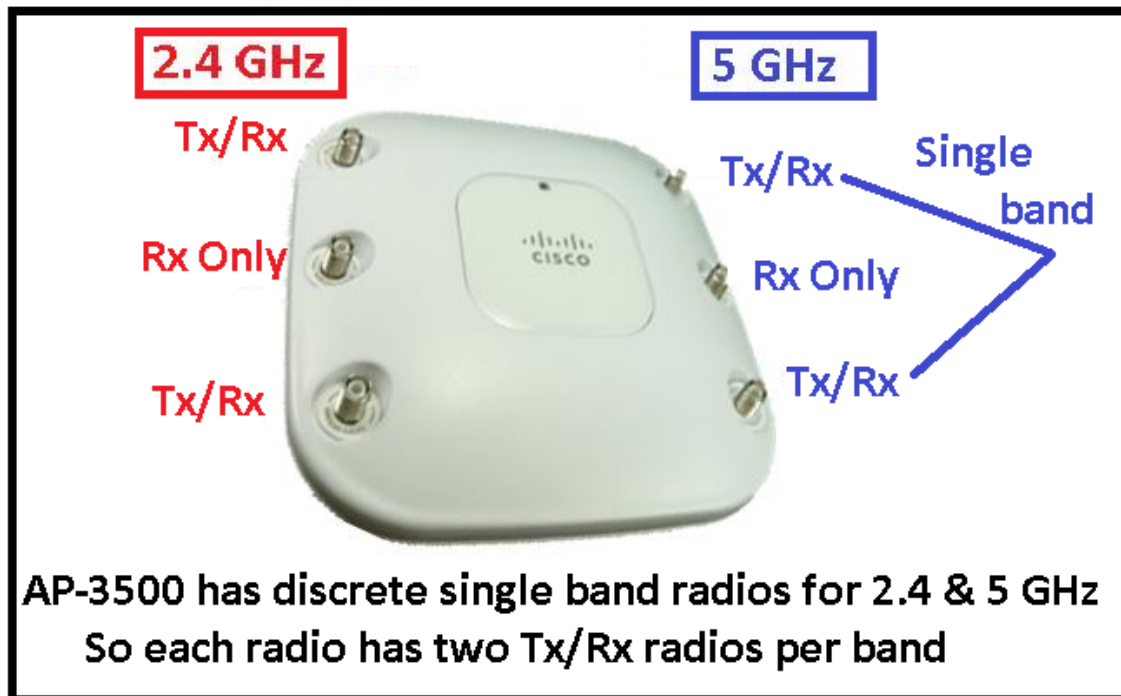
Figure 51: AP 3500i/e — 2x3:2 System (Two Transmitters, Three Receivers, Supporting Two Spatial Streams)

Spatial streams, the act of transmitting information out of more than one antenna port concurrently, requires that the AP have at least two or more transmitters and support elements of 802.11n (for example, support of multiple spatial streams).

With 802.11a/b/g, data rates were actual Mbps rates like 2, 11, and 54 Mbps and were done with one transmitter. The AP 3500 has two transmitters per band, so it supports 802.11n data rates up to 300 Mbps using two spatial streams.

With 802.11n, the different rates are called the Modulation and Coding Scheme (MCS) index value, and the value defines how many streams are used. The AP 3500 supported up to 300 Mbps (MCS rate 15) configured with a bonded channel and short guard interval (GI). (See Figure 52.) The MCS values correspond to actual data rates.

**Note**: 2x3:2 means two transmitters, three receivers supporting two spatial streams

| MCS | Coding | Modulation | Streams | Signal BW =20 MHz | | 40 MHz | |
|---|---|---|---|---|---|---|---|
| | | | | GI = 800 nS | GI =400 nS | GI = 800 nS | GI =400 nS |
| MCS0 | 1/2 | BPSK | 1 | 6.5 | 7.2 | 13.5 | 15 |
| MCS1 | 1/2 | QPSK | 1 | 13 | 14.4 | 27 | 30 |
| MCS2 | 3/4 | QPSK | 1 | 19.5 | 21.7 | 40.5 | 45 |
| MCS3 | 1/2 | 16-QAM | 1 | 26 | 28.9 | 54 | 60 |
| MCS4 | 3/4 | 16-QAM | 1 | 39 | 43.3 | 81 | 90 |
| MCS5 | 2/3 | 64-QAM | 1 | 52 | 57.8 | 108 | 120 |
| MCS6 | 3/4 | 64-QAM | 1 | 58.5 | 65 | 131.5 | 135 |
| MCS7 | 5/6 | 64-QAM | 1 | 65 | 72.2 | 135 | 150 |
| MCS8 | 1/2 | BPSK | 2 | 13 | 14.4 | 27 | 30 |
| MCS9 | 1/2 | QPSK | 2 | 26 | 28.9 | 54 | 60 |
| MCS10 | 3/4 | QPSK | 2 | 39 | 43.3 | 81 | 90 |
| MCS11 | 1/2 | 16-QAM | 2 | 52 | 57.8 | 108 | 120 |
| MCS12 | 3/4 | 16-QAM | 2 | 78 | 86.7 | 162 | 180 |
| MCS13 | 2/3 | 64-QAM | 2 | 104 | 115.6 | 216 | 240 |
| MCS14 | 3/4 | 64-QAM | 2 | 117 | 130 | 243 | 270 |
| MCS15 | 5/6 | 64-QAM | 2 | 130 | 144.4 | 270 | 300 |

Figure 52: MCS: Two Spatial Stream Bonded Channel Supports up to 300 Mbps

Unlike the AP 3500, the newer AP 3600 supports 3SS with twice as many transmitters (four per band), which enables faster data rates of up to 450 Mbps. There is an extra radio for redundancy and enhanced performance both upstream and downstream. The AP 3600 can also beamform to 3SS clients. The AP 2600 is similar, but the redundant radio is for upstream (as it is a receive only); the redundant radio is unable to beamform to 3SS clients but can beamform at the other non-3SS rates.

The dual-band design of the AP 3600 offers a total of eight transceivers (transmitter/receivers) using only four antennas. (See Figure 53.) Four radios are used in each band, 2.4 GHz and 5 GHz.
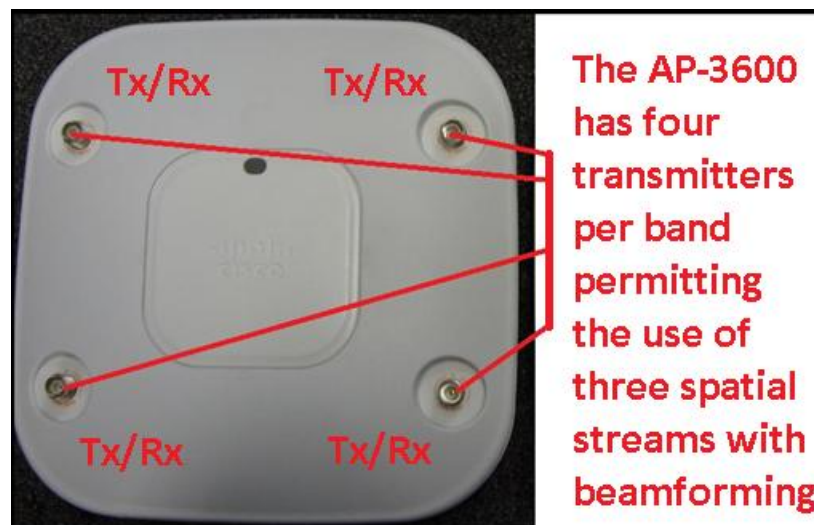


Figure 53: AP 3600: Four Transmitters and Four Receivers per Radio Band

The AP 2600, while similar to the AP 3600, is slightly different since it is a 3x4:3. This means that the AP 2600 also has four antennas to help on the receive (upstream signal) but uses only three transmitters on the downstream side.

The yellow sections of the MCS chart (see Figure 54) depict the faster data rates supported by the AP 3600. The AP 3600 supports 802.11a/b/g rates as well as 802.11n rates of MCS values 0-23.

| MCS | Coding | Modulation | Streams | Signal BW =20 MHz | | 40 MHz | |
|-----|--------|-----------|---------|-------------------|--------------|-------------------|--------------|
|     |        |           |         | GI = 800 nS | GI =400 nS | GI = 800 nS | GI =400 nS |
| MCS0 | 1/2 | BPSK | 1 | 6.5 | 7.2 | 13.5 | 15 |
| MCS1 | 1/2 | QPSK | 1 | 13 | 14.4 | 27 | 30 |
| MCS2 | 3/4 | QPSK | 1 | 19.5 | 21.7 | 40.5 | 45 |
| MCS3 | 1/2 | 16-QAM | 1 | 26 | 28.9 | 54 | 60 |
| MCS4 | 3/4 | 16-QAM | 1 | 39 | 43.3 | 81 | 90 |
| MCS5 | 2/3 | 64-QAM | 1 | 52 | 57.8 | 108 | 120 |
| MCS6 | 3/4 | 64-QAM | 1 | 58.5 | 65 | 131.5 | 135 |
| MCS7 | 5/6 | 64-QAM | 1 | 65 | 72.2 | 135 | 150 |
| MCS8 | 1/2 | BPSK | 2 | 13 | 14.4 | 27 | 30 |
| MCS9 | 1/2 | QPSK | 2 | 26 | 28.9 | 54 | 60 |
| MCS10 | 3/4 | QPSK | 2 | 39 | 43.3 | 81 | 90 |
| MCS11 | 1/2 | 16-QAM | 2 | 52 | 57.8 | 108 | 120 |
| MCS12 | 3/4 | 16-QAM | 2 | 78 | 86.7 | 162 | 180 |
| MCS13 | 2/3 | 64-QAM | 2 | 104 | 115.6 | 216 | 240 |
| MCS14 | 3/4 | 64-QAM | 2 | 117 | 130 | 243 | 270 |
| MCS15 | 5/6 | 64-QAM | 2 | 130 | 144.4 | 270 | 300 |
| MCS16 | 1/2 | BPSK | 3 | 19.5 | 21.7 | 40.5 | 45 |
| MCS17 | 1/2 | QPSK | 3 | 39 | 43.3 | 81 | 90 |
| MCS18 | 3/4 | QPSK | 3 | 58.5 | 65 | 121.5 | 135 |
| MCS19 | 1/2 | 16-QAM | 3 | 78 | 86.7 | 162 | 180 |
| MCS20 | 3/4 | 16-QAM | 3 | 117 | 130 | 243 | 270 |
| MCS21 | 2/3 | 64-QAM | 3 | 156 | 173.3 | 324 | 360 |
| MCS22 | 3/4 | 64-QAM | 3 | 175.5 | 195 | 364.5 | 405 |
| MCS23 | 5/6 | 64-QAM | 3 | 195 | 216.7 | 405 | 450 |

3 Spatial Stream MCS Rates (label for MCS16-MCS23 rows)

Figure 54: AP 2600/3600 Supports up to 450 Mbps (MCS Rates 0-23); AP 1600 (MCS Rates 0-15)

These additional MCS rates permit more choices for the client supporting 3SS when making rate-shifting decisions, since the rate-shifting algorithm maintains the best overall throughput connection.

## Clients That Support Three Spatial Streams

Clients with 3SS support are now more common. As the new 802.11ac specification becomes more accepted, many newer client adapters will have the newer chipsets and support 3SS as a subset to 802.11ac. Unlike many competitors, the AP 1600/2600 and the AP 3600 fully support all the DFS channels for more usable channels in the 5 GHz range. More clients, especially 802.11ac clients, will start to emerge and support these newer channels in 802.11n modes.

Currently the most popular 3SS client is the Apple 2011 MacBook Pro. It is based upon the Broadcom BCM4331 chipset and a small USB adapter (TEW 684UB) by Trendnet, based on the Ralink chipset.

The Intel 5300 and 6300 has supported 3SS for a long time. Perhaps because this card is installed in different hardware platforms, testers have observed good throughput (+320 Mbps) on many notebooks and reduced throughput (such as 240 Mbps) on other notebooks. If you experience low throughput with the Intel card, try a MacBook Pro or Trendnet adapter. If they perform well, try another notebook with

the Intel card or open a case with Intel or the laptop manufacturer for a possible remedy. During the AP 3600 beta trials, Cisco observed differences in performance with different notebooks using the Intel 6300 card.

**Note**: Sometimes it can be difficult to reliably maintain a 3SS link, since it is easy for the client to rate-shift out of the 3SS mode. The ability to maintain a 3SS link varies with the quality of the client and the test environment.

The AP 3600, with its extra radio per band, can use the extra redundant radio to beamform (thanks to ClientLink 2.0) and uses this to maintain the advantage of 3SS links. ClientLink 2.0 can also improve the overall performance of 802.11n clients using one, two, and three spatial streams and legacy .11a/g clients.

## Beamforming in ClientLink 1.0 and 2.0

ClientLink 1.0 was first introduced with the AP 1250 and the AP 1140; it is a method to create a stronger signal on the downlink side for 802.11a/g clients by hearing the clients on the uplink and then adjusting the transmitter timing so the signal appears much stronger at the client end.

This feature was previously user configurable. However, starting with 7.2 code stream, it is now on by default and is not user configurable because there is no benefit to disabling it.

The AP 3600 fully supports ClientLink 1.0 for 802.11a/g clients but has a greater advantage, for it also supports all 802.11n clients including one, two, and three spatial stream clients. This capability is called ClientLink 2.0. There is a distinct advantage with ClientLink 2.0 over the 802.11n enhanced beamforming specification, because ClientLink 2.0 works with all clients today and does not require any client sounding or support. (See Figure 55.)

| | 802.11n (EBF) Enhanced Beam Forming | Client Link 2.0 (CVBF) |
|---|---|---|
| WLAN Client | | Cisco Vector Beam Forming |
| Works for Multiple Spatial Stream HT Clients | Not yet | All |
| Works for 1 SS HT Clients | Not yet | All |
| Works for Legacy Clients (11 a/g) | None | All |
| General Requirements/Dependencies | | |
| Requires Client Cooperation/Support | Yes | No |
| Requires Use of Channel Time for Sounding | Yes | No |
| Can be Used w/ Clients Currently on Market | No | All 11a/g/n |

Figure 55: ClientLink 2.0

With beamforming technology, changing the timing of two transmitters creates a stronger signal for the receiver (for example, a client device). This is referred to as constructive interference. If the opposite happens, and the signals cancel each other out, it is called destructive interference. (See Figure 56.)
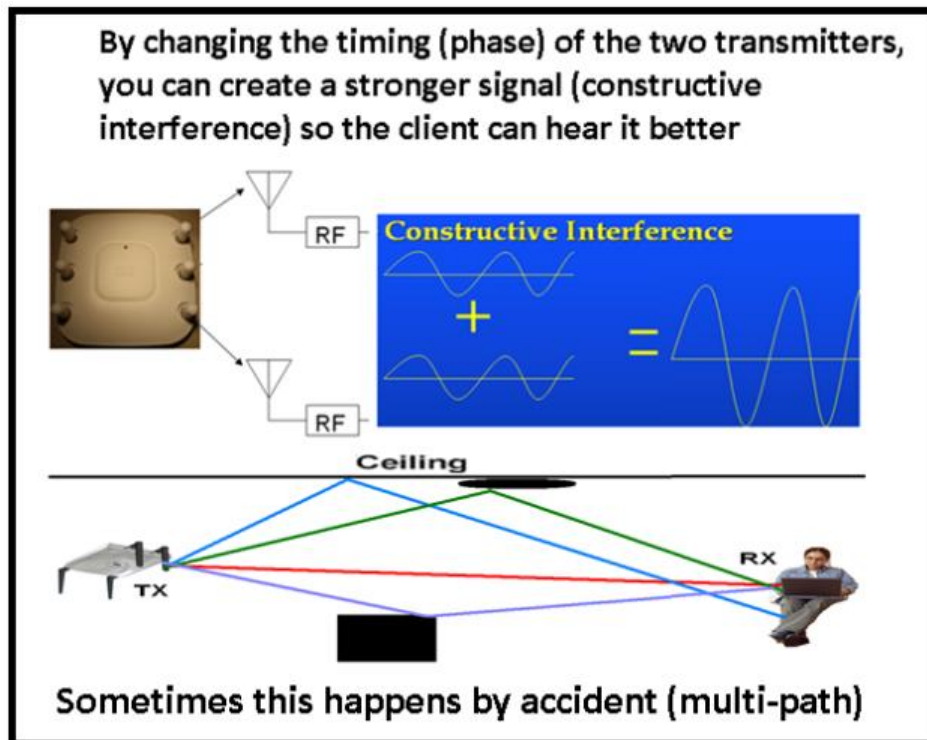
Figure 56: Beamforming, Constructive Interference, and Destructive Interference

Figure 57 provides a visual comparison of ClientLink 1.0, using one spatial stream, and ClientLink 2.0, using three spatial streams. Unlike the AP 3500, the AP 3600 provides multiple spatial streams using four transceivers for even greater performance. The AP 3600 can beamform to all 802.11a/g and 802.11n one, two, and three spatial stream clients. The signal is x3 as each stream is beamformed.
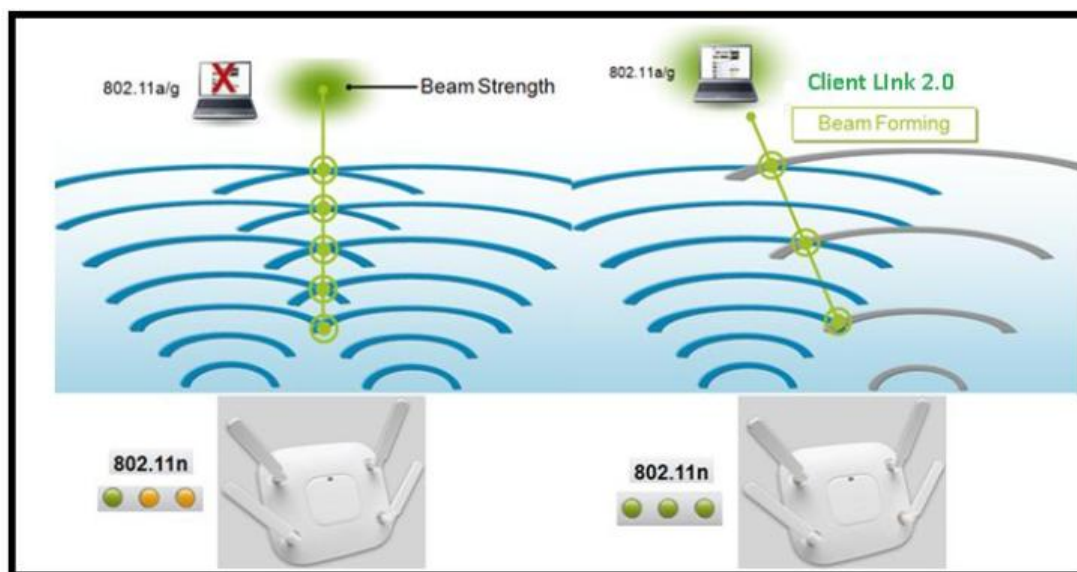


Figure 57: Example of ClientLink Directing the Signal to a Client

**Note**: In order to beamform to clients using three spatial streams, since three transmitters are used in the transmissions, the AP needs at least one additional radio to beamform. The AP 3600 has four radios per band and can beamform to clients using three spatial streams.

To summarize, ClientLink 2.0 takes the received signals heard from the client on the uplink and calculates how the multipath signal looked from those streams. Then, on the reciprocal side (transmit downlink), ClientLink 2.0 uses all four radios to figure out the optimal way to form the signal (transmit beamforming) to enable the client to best decode (receive the signal on the downlink) with the least amount of retries.

ClientLink 2.0 with an AP 3600 enables beamforming to all 802.11n clients, including 3SS clients, and can do so for up to 128 clients at a time. The AP 1600 supports fewer clients (32) and does not support 3SS. ClientLink 1.0 supported a maximum of 15 clients at a time. ClientLink 2.0 significantly improves throughput and coverage up to 60% on the downlink side for much better 802.11n client connectivity and for enhancing the Bring Your Own Device (BYOD) experience.

For more information on Cisco ClientLink 2.0, refer to the following URL:

http://www.cisco.com/en/US/prod/collateral/wireless/ps5678/ps11983/at_a_glance_c45-691984.pdf

# Site Survey Considerations

While ClientLink dynamically beamforms and helps to maintain a robust signal, which results in fewer retries, it was not designed to change the cell range. ClientLink creates a better connection experience, not a larger cell size.

For this reason, during a site survey, it is important to keep in mind that the AP 3600 cell sizes are generally the same or very similar to other Cisco access points. Figure 58 depicts typical ranges in the 1-54 Mbps range. While Cisco always recommends that you survey with the equipment you intend to deploy, an earlier survey done with an AP 3500, for example, would not be invalid for an AP 3600 deployment. Figures 59 and 60 provide examples of the modulation types and signal-to-noise ratio (SNR).
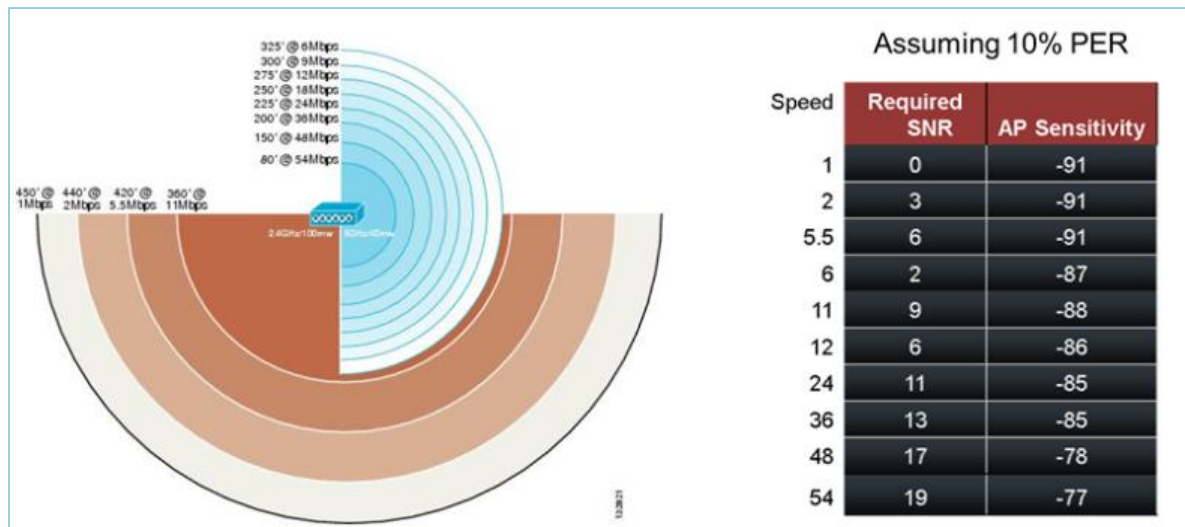
Figure 58: AP 3600 Site Survey Ranges (Typical Cell Sizes Unchanged; AP 3500 and AP 3600 Cell Sizes Unchanged)

| MCS Index 1/2/3 spatial stream | Modulation | Minimum Sensitivity 20 MHz | Required SNR (dB) |
|---|---|---|---|
| 0/8/16 | BPSK 1/2 | -82 | 1 |
| 1/9/17 | QPSK 1/2 | -79 | 4 |
| 2/10/18 | QPSK 3/4 | -77 | 6.5 |
| 3/11/19 | 16 QAM 1/2 | -74 | 9.75 |
| 4/12/20 | 16 QAM 3/4 | -70 | 13 |
| 5/13/21 | 64 QAM 2/3 | -66 | 17.25 |
| 6/14/22 | 64 QAM 3/4 | -65 | 18.75 |
| 7/15/23 | 64 QAM 5/6 | -64 | 19.75 |

Figure 59: Site Survey Sensitivity and SNR

**Note**: The SNR for 3SS is 28 dB, per IEEE, but Cisco RF engineers recommend 30-32 dB for best performance.

## CCNP Wireless CUWSS Quick Reference (eBook)

By Jerome Henry.
Published by Cisco Press.
Series: Quick Reference Sheets.

Published: Sep 9, 2010
Copyright 2011
Dimensions:
Pages: 96
Edition: 1st

While you may see this in print, the values seem a bit conservative to us

The AP-3600 can do better than this but some customers might use these values as it is a Cisco Press reference.

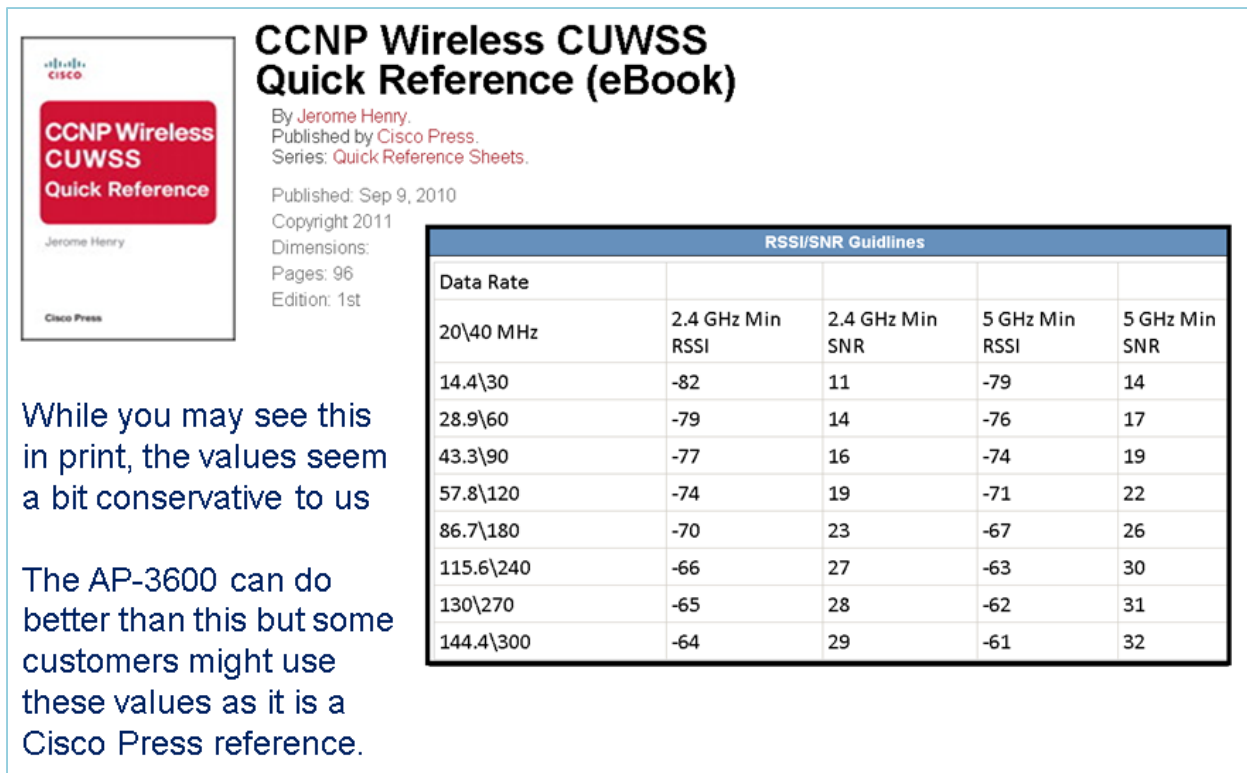| RSSI/SNR Guidlines | | | | |
|---|---|---|---|---|
| Data Rate | | | | |
| 20\40 MHz | 2.4 GHz Min RSSI | 2.4 GHz Min SNR | 5 GHz Min RSSI | 5 GHz Min SNR |
| 14.4\30 | -82 | 11 | -79 | 14 |
| 28.9\60 | -79 | 14 | -76 | 17 |
| 43.3\90 | -77 | 16 | -74 | 19 |
| 57.8\120 | -74 | 19 | -71 | 22 |
| 86.7\180 | -70 | 23 | -67 | 26 |
| 115.6\240 | -66 | 27 | -63 | 30 |
| 130\270 | -65 | 28 | -62 | 31 |
| 144.4\300 | -64 | 29 | -61 | 32 |

Figure 60: Site Survey Sensitivity, RSSI/SNR Guidelines, and SNR

# General Guidelines

Following are general guidelines for all access points.

- Always try to mount the AP as close to the users as possible for best performance. Be aware of the environment. For example, if hospitals have metal doors, coverage can change when the doors close. Old buildings can have metal grid work hidden under plaster or asbestos. Avoid mounting the AP or antennas near metal objects, since that may affect the coverage area.

- When using the 2.4 GHz frequency, the same one, six, and eleven channel scheme is used as in the 5 GHz channel scheme. (See Figure 61.) Avoid putting all APs on the same channel, and reuse channels if possible. See other Cisco deployment guides for more on this topic.
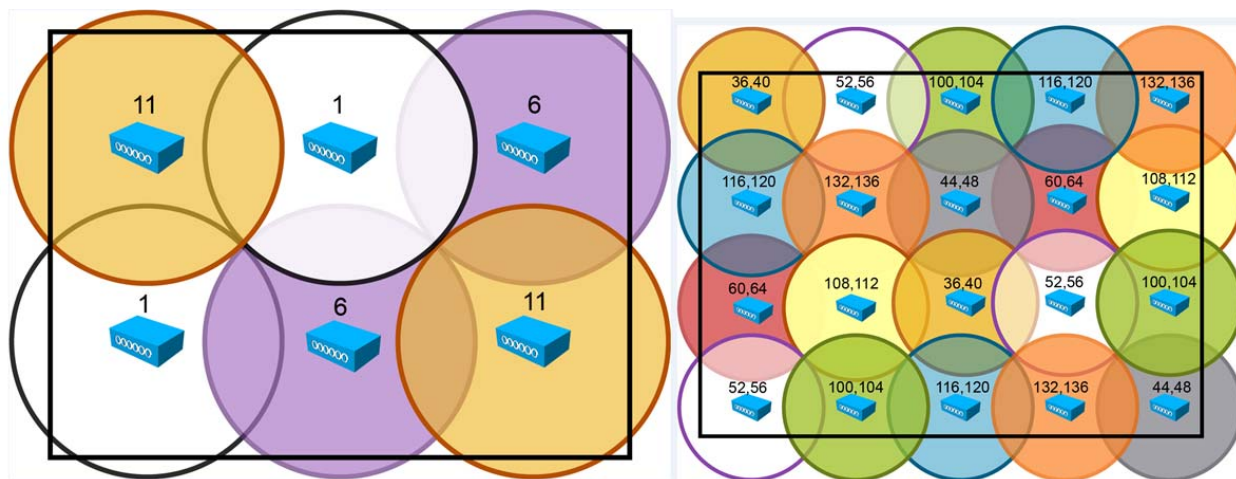
Figure 61: Example of Channel Usage in 2.4 and 5 GHz (Two Channels used if 40 MHz)

- Try to determine which clients will be used and check the coverage using those clients. For example, a PDA or Wi-Fi phone might not have the same range as a notebook or tablet.

  **Tip**: Verify coverage using the worst performing clients that you intend to deploy.

- If you require three spatial stream coverage for the fastest throughput or if you want the best BYOD experience, the AP 3600 and the AP 2600 with ClientLink 2.0 outperform the AP 3500. The AP 3600 can beamform to 802.11n clients, so it is important to understand the data requirements if you mix the AP 1260, 3500, and 3600 in the same areas.

- While site surveys are generally recommended, if the design is done at half power and Cisco RRM is in place, a limited site survey may be adequate for smaller venues. In very challenging environments such as train connectivity, Gas & Oil verticals, large hospitals, and so forth, you can contract with the Cisco Advanced Services team to help or to perform your installation. Contact your Cisco account team for more information.

- The AP 3600 was introduced in the 7.1.91 or higher code stream and is supported by the following: Cisco 2500, 7500, 5508, and WiSM2 Series Controllers, WCS 7.0.220 or higher, and NCS 1.1 or higher. The AP 1600 and the AP 2600 were introduced in the 7.4 release.

- The rule of thumb coverage plan is: one AP per 5,000 square feet for data and one AP per 3,000 square feet for voice and location services.

- Some clients (especially older ones) do not support the UNII-2 extended client channels 100-140; therefore, if you have older clients, you may want to disable them in the DCA channel list.

  **Note**: The newer 802.11ac clients support these channels, and more clients are starting to support these channels all the time.

# Examples of Improper Installations

It is very difficult to provide good Wi-Fi service with an improper installation, so use common sense when mounting devices:

- Keep the AP away from clutter and metal objects. (See Figures 62 and 63.)
- The AP should be level and secure so that it does not sway or move. (See Figure 64.)
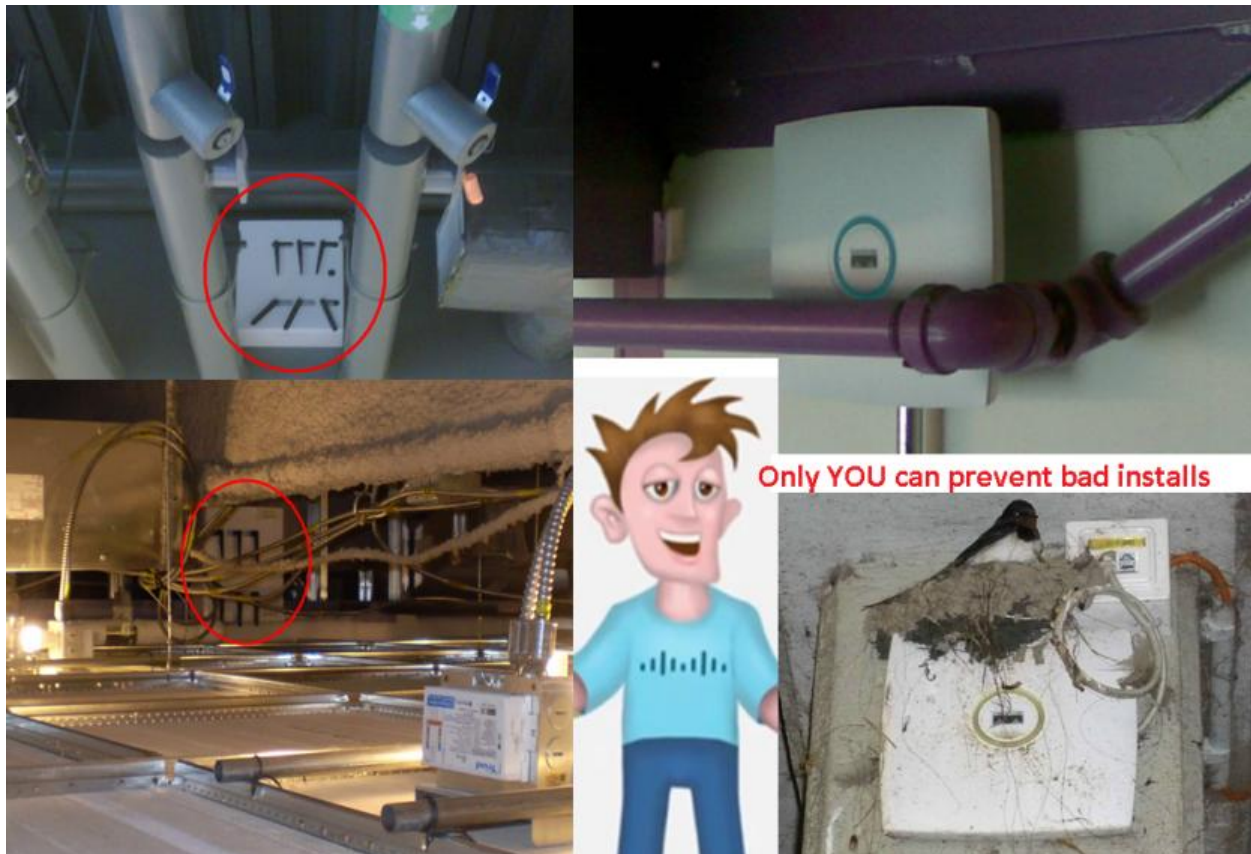- Try to locate the AP as close to the users as possible.



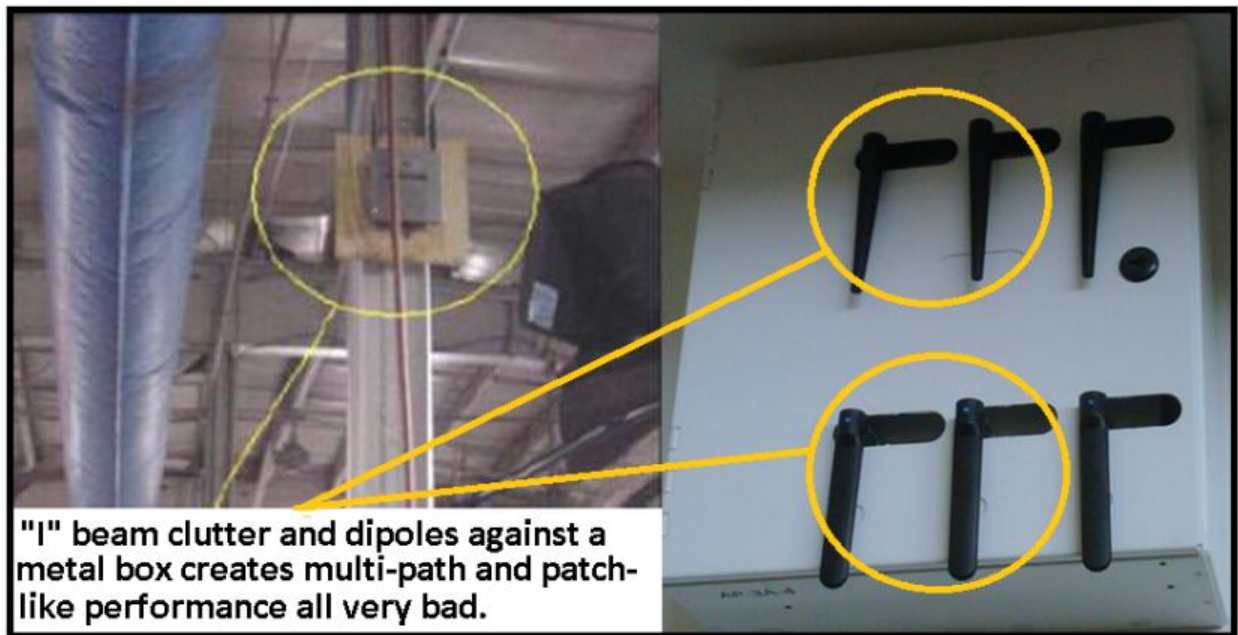Figure 62: Improper Installation: AP near Metal and Clutter

"I" beam clutter and dipoles against a metal box creates multi-path and patch-like performance all very bad.

Figure 63: Improper Installation — Antennas Against Metal



Figure 64: Improper Installation — AP not Level or Stable

**Tip**: When mounting antennas outside, always mount with the antenna leads and drain holes down so that rainwater does not enter the antenna. This approach is not necessary for indoor mounting. (See Figure 65.) Use Coax-Seal to protect against weather exposure but do not obstruct the drain holes. (See Figure 66.)
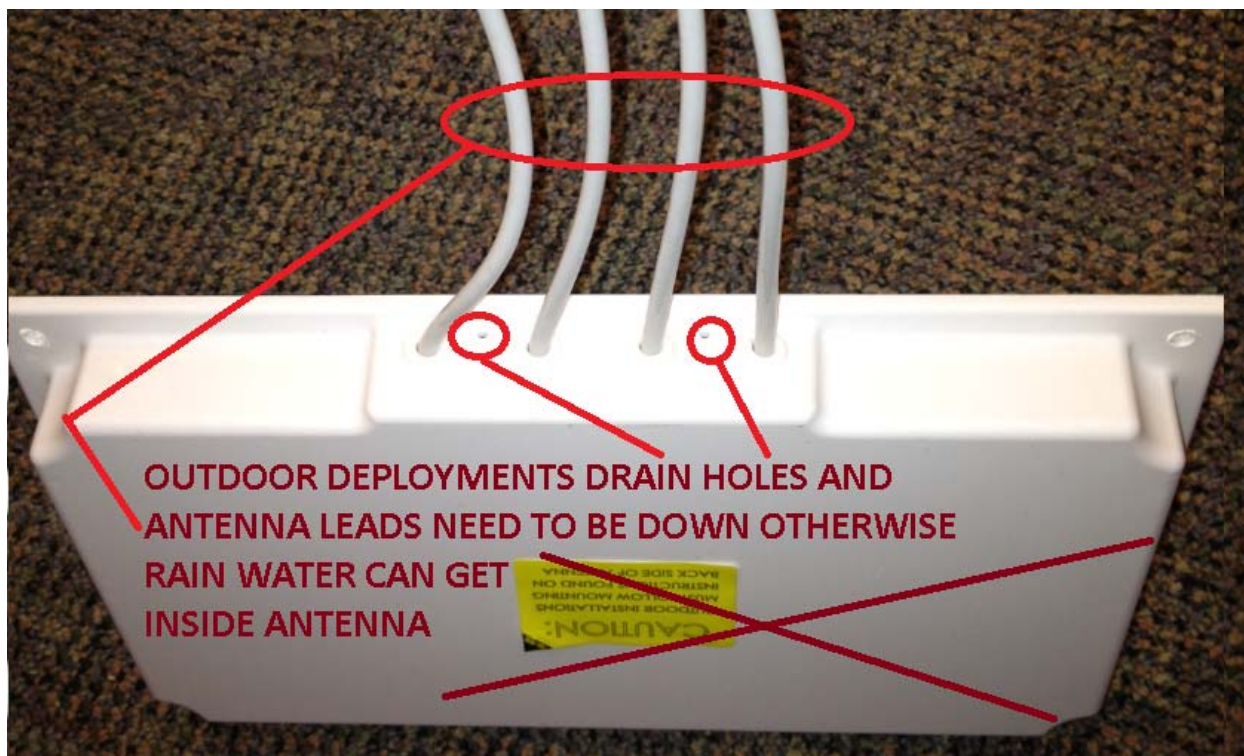
Figure 65: AP Mount with Antenna Leads and Drain Holes Down



Figure 66: Sealant

# Questions and Answers

Q1: Which AP is best for manufacturing and warehouse areas?

A1: In general, the AP 2600e or the AP 3600e is the first choice because these external antenna models have the highest operating temperature range -20 to 55°C. The AP 1600 can also be used but has a slightly lower operating temperature -20 to 50°C. If temperature is not a concern, use an internal antenna model (AP 1600i, 2600i, and 3600i).

Q2: What if I am in a country where the regulatory agency may not approve the AP to be used outdoors because of UNII-1 band restrictions? What if I wish to use higher gain antennas?

A2: Consider the Cisco Mesh products (1550 Series) or look for access points ending in "P" (for professional install), such as the 3502P Series or Cisco outdoor bridging products.

Q3: Which AP is best for high-density deployments?

A3: Both the AP 2600 and the AP 3600 have virtually identical AP density for coverage-based design. Capacity-based design (smaller cells) yields a slightly higher average cell capacity with the AP 3600 when using 3SS devices and yields an even higher density when using the optional 802.11ac module.

Q4: Cisco has a newer Power Injector (AIR-PWR-INJ5). How is this different from the (AIR-PWR-INJ4)?

A4: The newer AIR-PWR-INJ5 is an 802.3af (15.4W injector). It is a low cost injector for use with the AP 1600 and the AP 2600 and can also be used with the AP 3600 without the optional module. The AIR-PWR-INJ4 is a more powerful injector designed to work with the AP 3600 with optional modules.

Q5: Can industrial wireless motion or smoke detectors cause WLAN interference?

A5: Yes, some products such as United Technologies DD475 and Optex MX-50 operate in the 2.4 GHz band as do other wireless chimes, cameras, and industrial equipment from other manufacturers.

Q6: Any other thoughts when installing wireless access points?

A6: When deploying wireless installations, keep the following guidelines in mind:

- Place the AP as reasonably close to the actual users as possible.
- Make sure you have coverage (to a known requirement), and compensate for nulls or dead spots, regardless of what product you choose to deploy. Conduct a site survey.
- Base the installations on lessons learned from the site survey. The better the survey, the less likely connectivity problems will occur.
- Cisco has an Advanced Services team that can perform WLAN surveys or help with the wireless design if a Cisco partner is not available or able to do same.
- When possible, use the Cisco brand antennas listed in this guide. They have orange bands.
- Do not mount antennas against metal objects. Antennas work best when there are no obstructions in the path.
- The AP 1600, 2600, and 3600 are not weatherproof and have an IP rating of 40.

# Useful URLs

AP 3600 datasheet: http://www.cisco.com/en/US/products/ps11983/index.html

AP and controller datasheets: http://www.cisco.com/en/US/products/hw/wireless/index.html

Cisco antenna reference guide: www.cisco.com/go/antenna-ref

Why buy Cisco brand antennas:
http://www.cisco.com/en/US/prod/collateral/wireless/ps5678/ps10981/white_paper_c11-671769.pdf

Antenna patterns and their meanings:
http://www.cisco.com/en/US/prod/collateral/wireless/ps7183/ps469/prod_white_paper0900aecd806a1a3e.html

Cisco Guest Access Deployment Guide:
http://www.cisco.com/en/US/docs/wireless/technology/guest_access/technical/reference/4.1/GAccess_41.html

Cisco Schools WLAN Deployment Guide:
http://www.cisco.com/en/US/docs/solutions/Verticals/Education/SRA_Schools/schoolSRA_wlan_sba.pdf

The Apple Bonjour / Apple TV Deployment Guide:
http://www.cisco.com/en/US/partner/products/hw/wireless/ps4570/products_tech_note09186a0080bb1d7c.shtml

Optimizing Enterprise Video Over Wireless LAN:
http://www.cisco.com/en/US/prod/collateral/wireless/ps6302/ps8322/ps10315/ps10325/white_paper_c11-577721.html

Cisco 7925 IP Phone deployment guide:
http://www.cisco.com/en/US/docs/voice_ip_comm/cuipph/7925g/7_0/english/deployment/guide/7925dply.pdf

Cisco Mobility Services Engine – WLAN location deployment guide:
http://www.cisco.com/en/US/products/ps9742/products_tech_note09186a00809d1529.shtml

WLAN Design Guide for High Density Client Environments in Higher Education:
http://www.cisco.com/en/US/prod/collateral/wireless/ps5678/ps10981/design_guide_c07-693245.pdf

Mobility Design Guides:
http://www.cisco.com/en/US/netsol/ns820/networking_solutions_program_home.html

Software support and downloads: http://www.cisco.com/tac